

CALIFORNIA
AGRICULTURAL EXTENSION SERVICE

CIRCULAR 115

April, 1940

BEEF PRODUCTION IN CALIFORNIA

H. R. GUILBERT AND
LOUIS H. ROCHFORD

Coöperative Extension work in Agriculture and Home Economics, College of Agriculture,
University of California, and United States Department of Agriculture coöperating.
Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914.
B. H. Crocheron, Director, California Agricultural Extension Service.

THE COLLEGE OF AGRICULTURE
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

CONTENTS

	PAGE
Status of the industry.....	3
Comparative feed-consuming power of animals.....	8
Beef supply and demand trends.....	9
Production changes.....	17
Production areas.....	18
Weather data.....	27
Production costs.....	30
The dressed product.....	31
Nutrient requirements and cattle feeds.....	37
Dry matter and total digestible nutrient requirements.....	37
Protein requirements.....	37
Minerals.....	39
Vitamin requirements.....	42
Water requirement.....	44
Characteristics of range forage.....	44
Characteristics of harvested roughages, grains, and by-products.....	52
Preparation of feeds.....	59
Determination of the most economical feeds.....	60
Production of feeder cattle.....	66
Selective breeding and culling.....	66
Percentage calf crop.....	73
Growth and development of feeders.....	81
Adjustment of cattle numbers to feed supply.....	86
Management practices.....	87
Selling policy.....	91
Fattening cattle.....	92
Rate and economy of gain.....	93
Fattening cattle on pasture.....	104
Feed-lot rations.....	111
Creep-feeding of calves.....	120
Necessary margin or spread.....	122

BEEF PRODUCTION IN CALIFORNIA

H. R. GUILBERT¹ AND LOUIS H. ROCHFORD²

THE PRIMARY FUNCTIONS of beef cattle in California are to harvest, convert, and market products grown on the range, pasture, and farm lands of the state and to utilize important by-products of industries. In performing these functions, the cattle manufacture a concentrated, high-quality protein food that is consumed chiefly within the state.

This circular deals with the principal factors that influence beef-cattle production, management, and marketing practices in California, and the efficiency of the animals in performing their specific functions.

The circular is divided into four parts. The physical conditions and economic background that exert an important influence over the problems of the industry and the methods used by stockmen are described in the first part, "Status of the Industry" (pages 3 to 36).

The general requirements for the proper nutrition of beef animals and the characteristics of the principal feeds that cattle consume in this state are described in the second part, "Nutrient Requirements and Cattle Feeds" (pages 37 to 65).

The third part, "Production of Feeder Cattle" (Pages 66 to 91), deals specifically with the breeding herd and young growing animals. It includes recommendations on breeding practices and on feeding and management necessary to produce high-quality feeder cattle.

The fundamental principles to be observed in the final or finishing stage of beef production and definite suggestions for obtaining greatest efficiency from the animals during this period are given in the fourth part, "Fattening Cattle" (pages 92 to 125).

STATUS OF THE INDUSTRY

Forage grazed from the range and pasture land exceeds, by far, the volume of any other crop or by-product to be utilized by livestock in California. Grazing lands comprise about 60 per cent of the total land area of the state after accounting for cultivated lands, dense forests and brush, desert, inaccessible areas, and other parts from which grazing is excluded. They constitute 65 per cent of the total area in farms. The only important agricultural use of this great portion of the state is in the production of meat, milk, and wool.

¹ Associate Animal Husbandman in the Experiment Station.

² Extension Specialist in Animal Husbandry.

Range and Pasture Crops.—The quantity and quality of forage and the producing capacity of California grazing lands vary widely because of great extremes in topography, climate, precipitation, and type of soil. Because of the extremes, significant differences are found in the class, age, type, and quality of range cattle that can most efficiently utilize the forage produced. Different systems of management are also required to use adequately, yet conserve, these varied types of grazing lands.

The potential productivity of several million acres of grazing land is curtailed because of the checkerboard pattern of its ownership and control within distinct areas. The grazing lands owned by many stockmen are interspersed through federal and state lands, or through tracts owned by railroad, oil, or lumber companies; or they may adjoin abandoned homesteads or other unregulated ranch property of absentee owners. In some sections wild-land acreages privately owned and reserved for special recreational purposes, are intermixed with private livestock ranges. Such mixture of ownership, representing diversified viewpoints and objectives, often presents practical problems for most efficient use and conservation of range lands. In some large areas lack of coördinated effort prevents advancement of constructive range-management practices such as brush and rodent control, water development, proper fencing, and judicious grazing. The problem is greatest in those sections involving lands for which definite tenure has not been established.

About 57 per cent of the total land area of California is in private ownership, nearly three fourths of which is classified as grazing land. Most of the lands of highest grazing capacity are included in farms and ranches. These lands are owned in tracts varying from a few acres to several hundred thousand acres. Some of the largest tracts represent old Spanish grants with private ownership dating back to early California history. Railroad, lumber, and oil companies own the greater part of the remaining private lands not in farms, much of which is utilized through grazing. Range lands held primarily for recreation, abandoned homesteads, and isolated tracts held by absentee owners represent a sizable acreage on which livestock is grazed.

Over 40 per cent of the land area in California is in federal ownership. Nearly all of the better federal grazing lands are located within the boundaries of the national forests or within the organized grazing districts of the public domain.

The net acreage of the eighteen national forests in California represents about 20 per cent of the land area of the state. The national forests are administered by the Forest Service of the United States Department

of Agriculture. The California forests comprise what is known as Region 5, the administrative office of which is located in San Francisco.

According to the United States Forest Service, the principal uses of the national forests are for: (a) Watershed management; (b) timber production; (c) livestock grazing; (d) recreation and wild life.

Forest Service estimates show slightly over 50 per cent of the national

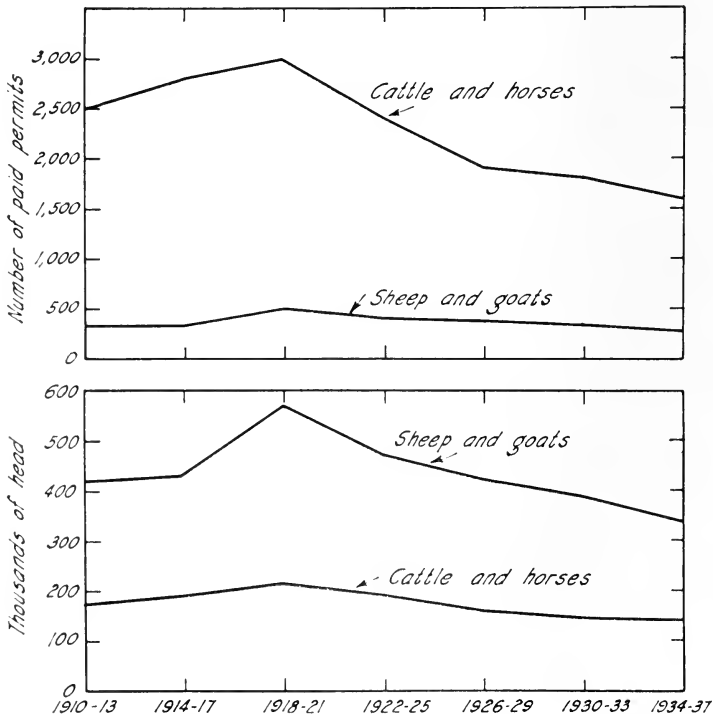


Fig. 1.—Upper panel: Trend in numbers of paid permits for domestic livestock grazed on national forests of California, from 1910 to 1937, four-year averages. Lower panel: Trend in numbers of domestic livestock grazed under paid permit on national forests. (Data from United States Forest Service, California Region.)

forest area to be suitable for grazing of livestock. National forests in California comprise only about one fifth of the total national forest area of the eleven western states, while nearly one half of the human population of these same states is located in California. Thus competition for the use of the national forests in California by the various interests is keen and sometimes conflicting. The national forests were established in 1909. Since their formation domestic livestock has grazed on these forests under paid permit. Figure 1 shows the grazing use of the California national forests for the period 1910–1937. It will be seen from

these charts that the peak of grazing use in this period was reached in the years 1918–1921. Since that time there has been a downward trend in both permits and numbers of livestock grazed on these lands. More livestock graze on the national forests located in the northeastern portion of the state and on those situated in the high Sierras than on the national forests of the southern and coastal regions. On an animal-unit basis cattle represent a more extensive grazing use of California national forests than do sheep. National-forest grazing lands supply feed for about 10 per cent of California's beef cattle for a period of 3 to 5 months of the year. The forage is of vital importance to stockmen in certain areas and is essential to proper use of commensurate privately owned lands.

The public-domain lands comprise about 14 per cent of the total land area of California. Most of these lands are located in the southeastern and northeastern parts of the state. These grazing lands are administered by the Division of Grazing of the United States Department of the Interior. The Taylor Grazing Act of 1934 provided for regulation of grazing on the public domain and authorized the incorporation of large areas into grazing districts. Two such districts, commonly referred to as Taylor Grazing Districts, have been established in California and comprise about 28 per cent of the total public-domain area of the state. The present status of these districts is as follows:³

District No. 1, located in Kern and Inyo counties, was established April 8, 1935. It comprises an area of 3,472,000 acres, about 63 per cent of which is public land reserved for grazing of livestock. In 1938 there were 226 permits issued for the grazing of 23,989 head of cattle in the district, and 186 permits issued for grazing 231,960 head of sheep.

District No. 2, located in Modoc and Lassen counties, was established April 8, 1935. It comprises an area of 3,980,000 acres, about 44 per cent of which is public land reserved for grazing of livestock. In 1938 there were 497 permits issued for grazing of 54,696 head of cattle in this district and 323 permits issued for grazing of 196,452 head of sheep.

For each district, advisory boards of local stockmen have been formed to make recommendations to administrative officials as to grazing regulations, management practices, range improvements, and other matters relating to the conservation and use of the land involved.

Feeds from Cultivated Lands.—A large part of the field crops of California and their by-products is consumed by livestock. To a lesser extent livestock provides the market for products from other crops. It is impossible, however, to state accurately the portion of each crop that is fed to animals and to delineate closely the rôle of beef cattle in their use.

³ Information supplied by L. A. Brooks, Regional Grazier, Reno, Nevada.

Table 1 indicates the relative amounts of certain leading California crops and their by-products which were available to be marketed through livestock during the period 1933-1937.

Every year a substantial amount of cull and substandard fruit and

TABLE 1
ESTIMATED ANNUAL PRODUCTION OF CERTAIN CALIFORNIA CROPS AND THE PORTION
AVAILABLE FOR LIVESTOCK
(Average for period, 1933-1937)

Crop	Acreage	Production, tons	Estimated portion available for livestock
Alfalfa hay.....	694,000	2,882,000	Nearly all utilized by livestock, principally cattle and sheep. Small portion to rabbits, poultry, and swine.
Grain hay.....	695,000	976,000	
Other hay.....	340,000	446,000	
Barley (threshed).....	1,079,000	708,000	60 to 70 per cent of the grain. Most of straw, if conserved.
Grain sorghums (threshed).....	120,000	99,000	Nearly all of grain and fodder except grain used for seed purposes.
Wheat (threshed).....	747,000	425,000	About 15 per cent of grain. Most of straw if conserved.
Beans (threshed).....	1,678,000	657,000	Cull beans representing at least 5 per cent of total. Most of straw, if conserved.
Oats (threshed).....	106,000	52,000	Nearly all of both grain and straw.
Rice (threshed).....	120,000	183,000	About 15 per cent of grain. Most of straw, but straw has very low value.
Silage corn.....	15,000	130,600	All for livestock use.
Sugar beets.....	121,000	1,678,000*	All of tops and pulp. (Weight of green tops is about 50 per cent of the weight of beets produced. Weight of pulp, dry basis, after processing beets represents about 5 per cent of the beet tonnage sliced.)
Cotton.....	326,000	89,000†	Approximately 48,000 tons cake and meal, 25,000 tons hulls, and 5,000 tons whole cottonseed produced annually for livestock feed.
Flax.....	33,000	14,000†	About 9,000 tons of linseed meal and cake produced annually for livestock feed.
Cropland grazing.....	{ After harvest, a vast tonnage of feed is available on over 2,000,000 acres of grain, bean, and rice land (exclusive of straw produced) which may be utilized by livestock grazing. Also the aftermath from about 1,500,000 acres of hay land is obtainable only through grazing. No attempt is made to measure the volume of this cropland grazing.		

* Roots.

† Seed.

Sources of data:

Calculated from data in published reports of the United States Bureau of Agricultural Economics and California Coöperative Crop Reporting Service and from other unpublished sources.

vegetable products finds a market only through livestock. The aggregate tonnage of such products is of significant importance to both crop and livestock enterprises. There is no reliable way to measure their volume, which varies widely from year to year. Principal feeds from this type

of crop production include figs, raisins, prunes, peaches, pears, apples, potatoes, cantaloupes, carrots, artichokes, peas, and lettuce. Tables 8 and 9 show the digestible nutrients to be found in most of these products.

Industrial By-Products.—Livestock, by supplying a market for industrial by-products, is vitally important to many industries. In turn, these products aid materially in supplementing the feed resources of range, pasture, and farm lands. The principal industrial by-products are beet pulp, cane molasses, cottonseed and linseed products, brewers' and

TABLE 2

ESTIMATED ANIMAL UNITS IN CALIFORNIA ACCORDING TO CLASS OF LIVESTOCK*
(Average for period, 1933–1937)

Class	Animal units	Class	Animal units
Beef cattle.....	1,023,000	Horses and mules.....	227,000
Dairy cattle.....	959,000	Swine.....	151,000
<i>All cattle</i>	1,982,000	Other livestock (goats, rabbits, ducks, geese, etc.).....	100,000
Sheep.....	687,000		
Chickens and turkeys.....	278,000		

* One animal unit is equal to 1 mature cow, horse, or mule; 5 mature sheep or hogs; 75 mature chickens; 37.5 mature turkeys.

Sources of data:

Calculated from data in published reports of the United States Bureau of Agricultural Economics and California Coöperative Crop Reporting Service.

distillers' grains, orange pulp, grape and apple pomace, coconut meal, mill feeds, fish meal, tankage, meat scrap, and bone meal.

The characteristics, uses, and digestible nutrients in these crops and by-product feeds are given in the second part of this circular, "Nutrient Requirements and Cattle Feeds."

COMPARATIVE FEED-CONSUMING POWER OF ANIMALS

Table 2 shows the numbers of different classes of livestock in California converted to an equivalent feed-consuming-power basis; that is, animal units, and therefore indicates the relative importance of beef cattle in utilization of the feed resources outlined in the preceding paragraphs.

The total feed-consuming power of beef and dairy cattle for the period 1933–1937 was about equal; together these classes represented nearly 60 per cent of the total for all California livestock.

Cattle and sheep are adapted to the utilization of both roughages and concentrates. The feed-consuming power of swine and poultry is confined mainly to use of concentrates. Since California range, pasture, and harvested roughages supply a far greater tonnage of digestible nutrients than do concentrates grown in the state, it is logical that cattle and sheep

must be relied upon to market a much larger amount of California feed crops than the other classes of livestock.

Dairy cattle are considered to be more efficient than beef cattle in marketing of pasture and roughages when such feeds are near at hand, and located close to good markets for dairy products. When forage is grown under range conditions or located some distance from market, the beef animal or sheep markets such forage more efficiently than the dairy cow. The comparative efficiency of beef cattle and sheep in this respect is not greatly different, which perhaps partially accounts for their long history of competition on the western range.

BEEF SUPPLY AND DEMAND TRENDS

Cattle numbers in California remained fairly constant during the nineteen-year period, 1920–1938. In this same period the human population of the state increased about 70 per cent. California is now a deficit beef-producing area. Among the seventeen most western states, California and Washington, only, produce less beef than they consume. Meat consumption in California is increased by the large number of nonresidents who visit the state each year.

The past two decades have brought not only a great increase in extent of demand for beef and other meats in California, but also a marked change in the type of demand. In earlier years California demand was greatest for beef from mature slaughter animals weighing 1,100 to 1,400 pounds. Heavy grass-fat and hay-fed cattle met with favor, and very little, if any, premium was paid for animals fattened on concentrates. In more recent years meat retailers catering to a family trade have shown preference for beef carcasses produced from steers weighing 800 to 1,050 pounds and from heifers weighing 650 to 800 pounds. The demand for carcasses from heavier cattle is now largely confined to hotels, restaurants, and other establishments serving large numbers of people. The present-day California demand for slaughter steers and heifers is widest for "Medium to Good" and "Strictly Good" grades. There appears to be a growing demand for the "Good to Choice" and "Choice" grades. Only a very limited demand exists for the "Prime" grade of steers and heifers that possess a very high degree of finish.

The prevalence of outdoor living in populous sections of the state is a stimulus to roadside stands and eating establishments at pleasure resorts. Such outlets increase the demand for cheaper cuts and plainer carcasses. This situation is reflected in the relatively strong prices for slaughter cows and bulls as compared with midwestern markets.

Figure 2 shows the trend in per-capita consumption of meats in the

United States for the period 1900–1937. On the average, in this period, pork constituted 47.3 per cent, beef and veal 48.3 per cent, and lamb and mutton 4.4 per cent of the total per-capita consumption of all meats. Estimates⁴ indicate the California per-capita consumption of beef, veal, lamb, and mutton, to be considerably higher than the average for the nation. Per-capita consumption of pork and lard in California is below the average for the nation.

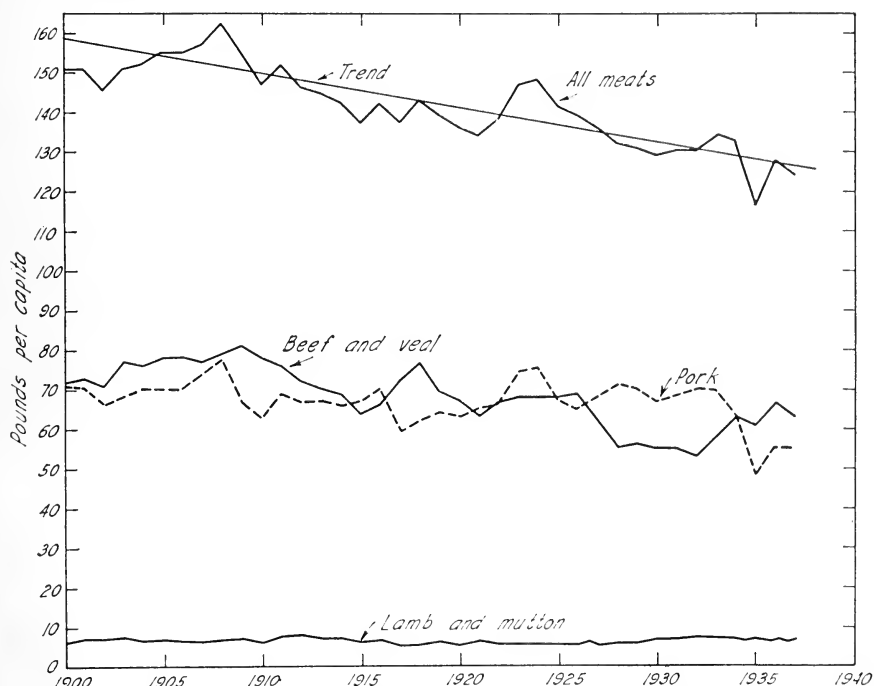


Fig. 2.—Average per-capita consumption of meats from total United States slaughter, from 1900 to 1937. (Data from: U. S. Dept. Agr. Bur. Agr. Econ. Live-stock, meats, and wool market statistics, and related data, 1937. Issued May, 1938.)

Stocker and Feeder Shipments into California.—Each year California draws on surplus-producing states of the West for many stockers and feeders. Figure 3 shows the number of such cattle shipped into California to vary widely from year to year. The available supply of different classes and grades in the surplus states, and the strength of California demand as compared with midwestern demand, are the important factors influencing the number shipped into the state. The late fall and winter prospects for grass on the lower ranges and the supply of harvested feeds largely control the extent of California demand. The bulk of such ship-

⁴ Estimates furnished by W. E. Schneider, Marketing Specialist, Federal-State Market News Service, San Francisco.

ments goes into the southern half of the state. The majority of the stockers and feeders are destined for grazing at least one and often two seasons. A lesser number go directly into feed lots. In recent years weaner calves and yearlings have made up most of the stocker and feeder shipments into California. Heaviest shipments come from Arizona, Texas, Nevada, and Oregon, with sizable shipments originating in Utah, Idaho, Colorado, Wyoming, and Montana. The greatest seasonal movement occurs in October, November, and December, when California stockmen are ready to restock their ranges or start feed-lot operations. About 60 per cent of the total annual shipments come in during these three months (fig. 4).

Slaughter-Cattle Shipments into California.—During the five-year period, 1934–1938, cattle and calves shipped into California for immediate slaughter represented 24.3 per cent of the state-total inspected slaughter for these classes of livestock. Most of the shipments originate in the states of Arizona, Texas, Utah, Nevada, Idaho, Colorado, Oregon, and New Mexico. During the winter and spring months scattered shipments come from several other states. The heaviest movement of cattle and calves into the state for immediate slaughter is in the period from October to March. The late summer and fall shipments are largely made up of grass cattle, while the winter and spring shipments are composed mainly of fed cattle. The seasonal movement is shown in figure 4.

Dressed and canned beef: An undetermined but significant amount of dressed beef is shipped into California annually from points as far east as Omaha and Kansas City. Canned beef, much of which is imported from South America, also regularly moves into the state for consumption here.

Cattle Shipments Out of California.—Shipments of cattle out of California for market elsewhere are occasional rather than regular and in most years very small in total volume. In some years during the late spring and early summer, supplies of grass-fat cattle may exceed the local demand, and if eastern demand is strong, grassers may be shipped eastward. Occasionally stockers, feeders, and fed cattle move from the state to outside markets.

Cattle and Calf Slaughter.—The trend in California slaughter of both cattle and calves has been upward during the fourteen-year period 1925–1938. In recent years other states have contributed an increasing number of both classes of animals for slaughter in California (figs. 5 and 7).

The monthly rate of slaughter for both cattle and calves is fairly constant, with marketings from California heaviest in the late spring and summer months as shown in figures 6 and 8.

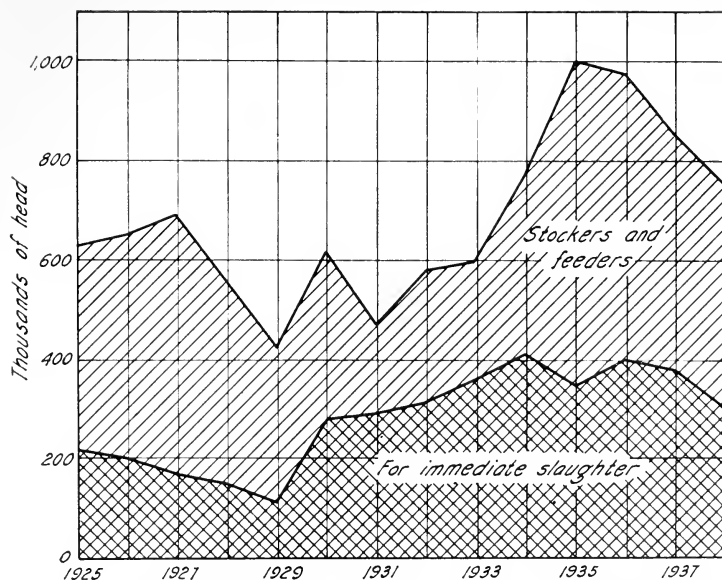


Fig. 3.—Cattle and calves shipped into California annually from 1925 to 1938. (Data for years 1925 to 1936 from: Scott, George A. California livestock statistics. California Coöperative Crop Reporting Service, Sacramento, California. October, 1937. Data for 1937 and 1938, by correspondence.)

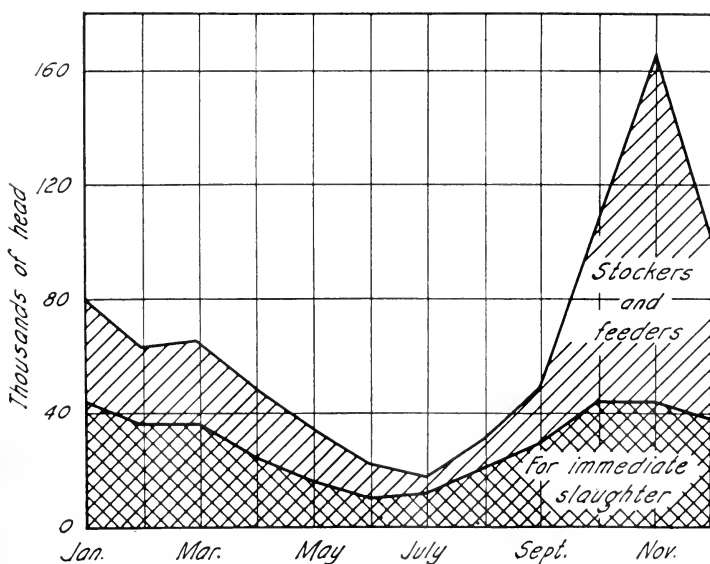


Fig. 4.—Cattle and calves shipped into California. Seasonal averages, from 1932 to 1938. (Data for years 1932 to 1936 from: Scott, George A. California livestock statistics. California Coöperative Crop Reporting Service, Sacramento, California. October, 1937. Data for 1937 and 1938, by correspondence.)

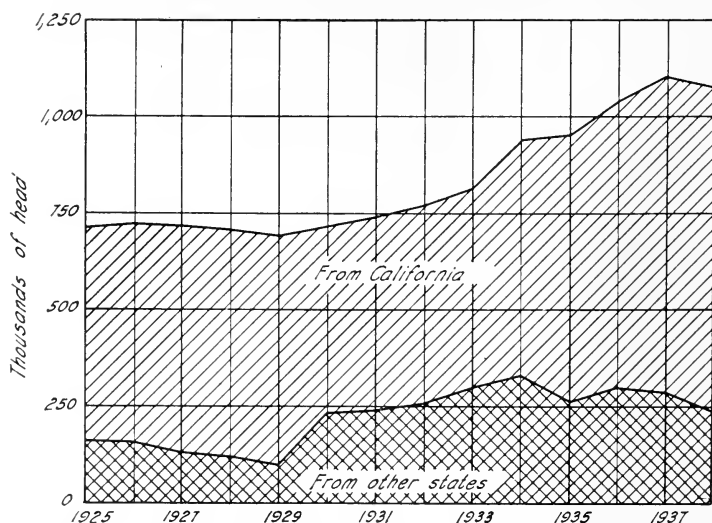


Fig. 5.—Slaughter of cattle in California under all inspection services, annually from 1925 to 1938. (Data for years 1925 to 1936 from: Scott, George A. California livestock statistics, California Coöperative Crop Reporting Service, Sacramento, California. October, 1937. Data for 1937 and 1938, by correspondence.)

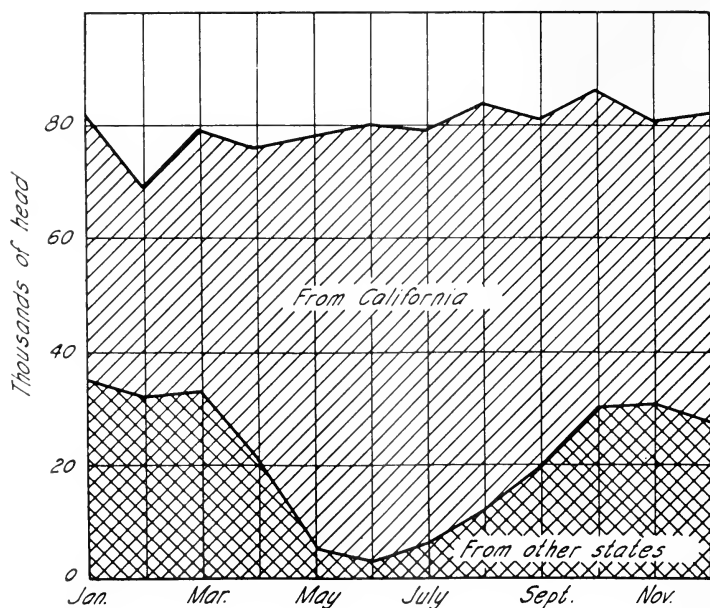


Fig. 6.—Slaughter of cattle in California under all inspection services, seasonal averages from 1932 to 1938. (Data for years 1932 to 1936 from: Scott, George A. California livestock statistics, California Coöperative Crop Reporting Service, Sacramento, California. October, 1937. Data for 1937 and 1938 by correspondence.)

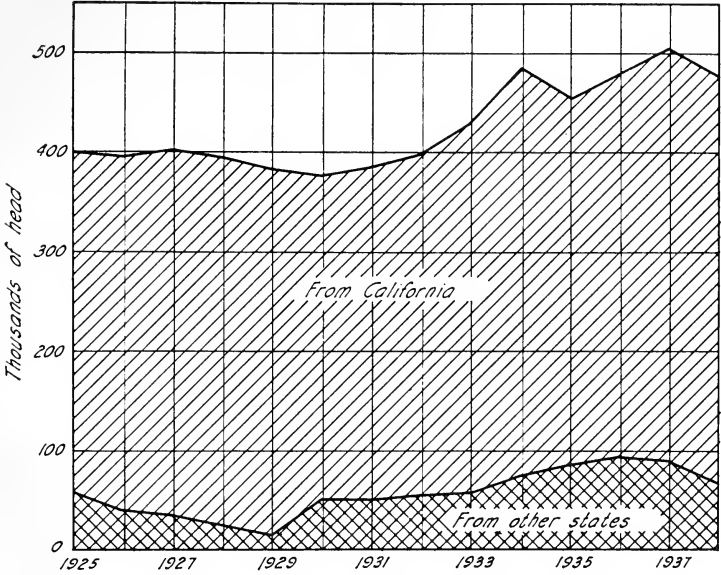


Fig. 7.—Slaughter of calves in California under all inspection services, annually from 1925 to 1938. (Data for years 1925 to 1936 from: Scott, George A. California livestock statistics. California Coöperative Crop Reporting Service, Sacramento, California. October, 1937. Data for 1937 and 1938, by correspondence.)



Fig. 8.—Slaughter of calves in California under all inspection services, seasonal averages for 1932 to 1938. (Data for years 1932 to 1938 from: Scott, George A. California livestock statistics. California Coöperative Crop Reporting Service, Sacramento, California. October, 1937. Data for 1937 and 1938, by correspondence.)

Combined records of cattle and calf slaughter for the five-year period 1934–1938 show the average percentage distribution for the different classes to be as follows: steers, 29.9; cows and heifers, 36.1; calves, 31.7; bulls and stags, 2.3.

Licensed slaughtering plants are found in most parts of the state. By far the greatest volume of slaughter is conducted in and near the two principal metropolitan areas, Los Angeles County and San Francisco Bay region. The percentage of the total inspected slaughter of the state occurring in each of these two areas during the period 1934–1938 was as follows:

	<i>Cattle</i>	<i>Calves</i>
Los Angeles County.....	47.13	34.66
San Francisco Bay area including Alameda, Contra Costa, Marin, San Francisco, San Mateo, Santa Clara, Solano counties.....	25.08	11.86
Total, both areas.....	72.21	46.52

Livestock slaughter records for California are fairly complete and from them it is estimated that inspected slaughter of cattle and calves accounts for more than 90 per cent of all such animals slaughtered within the state.

Markets.—Four factors govern largely the ability of the producer to purchase or sell cattle efficiently. They are:

1. Knowledge and judgment of cattle.
2. Knowledge of marketing channels.
3. Understanding of market classes and grades.
4. Information possessed as to current prices and demand for the cattle to be bought or sold.

The principal avenues now in use for marketing stockers and feeders in California are:

1. Direct from the breeder to the feeder who fattens the animals.
2. Direct from the breeder to the grazier for further grazing, who in turn sells to a feeder for finishing.
3. From the producer through a central market commission agency, either private or cooperative.
4. From the producer through a country commission agency, either private or cooperative.
5. From the producer through a speculator, trader, or order buyer, who in turn may sell through any of the various channels.
6. Direct to a packer buyer along with slaughter animals, the packer placing the "feeder sort" into the feed lot for finishing.

Slaughter cattle are customarily marketed through the following channels:

1. Direct to the packer buyer.
2. Through a speculator, trader, or order buyer to the packer.
3. Through a central market commission agency, either private or coöperative.
4. Through a country commission agency, either private or coöperative.

At the present time there are no reliable estimates available as to the trend in percentage of all cattle and calves which are marketed through the various agencies listed above.

Public or central markets: The system of marketing cattle through public or central markets is of relatively recent development in California as compared with other regions of the nation. Three public markets are now operating in the state under the supervision of the Federal Packers and Stockyards Administration. The Los Angeles market was opened in November, 1923; the San Francisco market, in March, 1927; and the Stockton market in August, 1933. The physical facilities at each of these markets are owned and operated by a stockyards company, which supplies pens and feed for the livestock. Commission agencies are located on each market, and any livestock to be sold through the market is consigned to one of these agencies for care and sale. Charges for yardage, feed, and sale of the livestock are subject to the approval of the Federal Packers and Stockyards Administration.

Market news service: In each livestock market center of the nation, an official market news service supervised by the federal Bureau of Agricultural Economics is maintained for the benefit of the livestock and meat industry. Daily, weekly, seasonal, and special reports on market supply, demand, and prices are issued through the press, the radio, and by letter. Specially trained men are employed to obtain and disseminate reliable market information to the public. In California the Federal-State Market News Service reports are issued from both Los Angeles and San Francisco. From San Francisco the local dressed meat trade is also reported. A uniform market reporting system based on standard classes and grades of livestock is employed throughout the nation. Publications giving illustrations and descriptions of these market classes and grades have been prepared by the Bureau of Agricultural Economics, United States Department of Agriculture.

PRODUCTION CHANGES

Since its earliest history, California has relied upon cattle as a major source of agricultural revenue, although many shifts have occurred in location of the animals and methods of their production and management.

In the early days of California, grass was the principal crop produced on fertile valley lands as well as on the rougher areas. Cattle and sheep were required to convert this crop into revenue. As the agriculture of the state developed, the so-called "range livestock" was pushed back to the poorer lands of the valleys, hills, and mountains, which were considered unfit for cultivation. In general the farmers were not stockmen, nor were the stockmen farmers. The result was a rather definite separation of farmers' interests from stockmen's interests with little recognized interrelationship. The opinion became prevalent that livestock grazing must be confined to very cheap land and that the good land must all go into cultivated crops. In certain areas the range animals were called upon to utilize hay and other low-grade roughages, but only a very small amount of concentrates and by-products was sold through them. In other words, the range cattle generally went direct to market rather than through the farm route. There were two principal reasons for this situation. First, the stockman was selling his cattle at mature age into a market that was satisfied with grass or hay-fed beef and which paid little if any premium for animals finished on concentrates. Second, the rapid growth of human population in the state, especially since 1910, greatly enhanced the demand for dairy products, and dairy cattle led all other livestock in marketing of harvested farm feeds and industrial by-products.

During the past decade, however, the picture has changed materially. The variety and amounts of feeds available to beef cattle have steadily increased. Local markets now demand more beef from lighter and younger animals of good quality that have attained desirable finish. As a rule, such animals bring a premium over prices paid for heavy grass cattle. To attain proper slaughter condition at 1,050 pounds or less, young animals require some supplemental feeding with both concentrates and roughages. While stockmen continue to rely principally on the range for maintenance of breeding herds, growing cattle, and in some areas for fattening of animals, there is a decided trend toward more feeding, both on pasture and in the feed lot. The shift in market demand has stimulated the establishment of private and custom feed yards located near markets and in the feed-producing areas. Simultaneously numerous

farmers have become interested in the fattening of cattle as a means of converting hay, grain, and irrigated pasture crops and for utilizing field clean-up. The leading influences now promoting the feeding of cattle by farmers in California are:

1. Necessity for crop rotation.
2. Need for improvement of soil fertility.
3. Restricted outlet for cash sale of grain and hay in some districts.
4. Growth of the sugar-beet industry.
5. Desire for diversification of farm enterprises

The increase in cattle feeding appears to be beneficial to the range cattle interests as well as to the farmer. In most instances the farmer is not a breeder of beef cattle but relies upon the range producer for his supply of feeder animals. With a widened outlet for feeder cattle, breeders and graziers now have the alternative of selling their animals as feeders or holding them for slaughter condition. Many range operators have found it advisable to sell their animals as feeders and to reserve their ranges for breeding and growing animals. On certain ranches where range forage is dependable and of high quality, the two- or three-year-old steer may utilize such feed as efficiently as a breeding cow, calf, or yearling, and in an average year can be depended upon to fatten for the early grass-cattle market.

The comparative number of beef and dairy cattle in California is an important consideration. Although all cattle contribute to the beef supply regardless of their primary use, the rate and quality of beef production from the two sources differ widely. In this state, a rather definite distinction exists in the purpose for which cows are maintained, and there is little shift in their principal use. The number of cattle in California kept mainly for beef purposes slightly exceeds the total number of animals of all ages in herds kept primarily for dairy purposes.

PRODUCTION AREAS

The production of beef cattle is of prominence in every region of the state and of major importance to the agriculture of at least two thirds of the counties. At the time of the last Federal Census (1935) the ten leading counties in number of beef cattle ranked as follows: Modoc, Tulare, Kern, San Luis Obispo, Merced, Santa Barbara, Monterey, Siskiyou, Fresno, and Madera.

The general characteristics of the different producing areas are here presented because of their interdependence in the production and marketing of cattle.

Northeast Mountain Area.—Beef cattle are of first importance to the agriculture of the area represented by Siskiyou, Modoc, Lassen, Plumas, Sierra, and parts of Shasta and Tehama counties, and production here is significant from a state standpoint since Modoc and Siskiyou rank among the ten leading beef-producing counties of California. Most of the producers maintain breeding herds and very few cattle are purchased from outside areas except purebred seedstock. The principal crops to be utilized by cattle are range forage and hay. Grain and other feed crops are relatively unimportant except in the Tule Lake district. In the past the predominant practice has been to sell the cattle for slaughter as grass- or hay-fed animals. There is now a tendency toward the sale of yearling feeders into the lower valleys for fattening. The market cattle are sold chiefly in the season from August to December.

This area, mostly situated at altitudes of 2,000–5,000 feet, has a rigorous winter climate which generally necessitates feeding of all cattle for from three to five months. Grass hay, mixed meadow hay, and alfalfa are the principal harvested roughages. On ranches where the practice has been to sell heavy grass- and hay-fed cattle, such animals usually have had preference of feed over breeding herds and young growing stock. With the trend towards sale of yearling feeders, there is now a tendency for the breeding herds and weaner calves to receive better care and feed. Some stockmen feed small amounts of grain or cottonseed cake to calves during the winter to promote their continuous growth.

At the lower elevations the growing season extends from April to October; in the higher elevations it may be confined to the period from late May to early September, with light summer frosts not uncommon. Many stockmen have permits to graze cattle on the adjacent national forests and public-domain lands. Others depend entirely on privately owned range, while some make a combined use of private and public land. Grazing in the national forests is restricted to the summer months. Heaviest use of the public-domain land is in the spring and fall months. Both perennial and annual range species are important forage. When the cattle come from the range in the fall, extensive use is made of the aftermath from hay lands.

Brush encroachment has decreased the amount of available grazing land in certain localities. On some ranges cattle and other domestic livestock must compete with large numbers of deer and antelope for use of forage.

Sacramento Valley.—Harvested roughages, grain, and cropland pasture are the leading products to be utilized by beef cattle in the Sacramento Valley, with native range and pasture of lesser importance in most

districts of it. Sheep offer strong competition for these feeds in this very important early-spring-lamb-producing section which maintains about 40 per cent of the sheep of the state. There is now a trend toward more fattening of cattle by farmers in the valley, especially in the beet-growing sections. A few large central feeding plants are located here with some of the cattle owned by packers. Most of the feeder cattle are brought in from other parts of California and from outside the state. The normal demand for feeders in the Sacramento Valley exceeds the supply available in adjacent northern California areas. The heaviest seasonal demand for feeders is from August to November, immediately following the harvesting of farm crops. A lesser feeder demand continues for the remainder of the year. Where feeding is to be confined mainly to pasturing of beet tops, two-year-old cattle or older meet with favor. For lot feeding, cattle of yearling age are popular. A few calves are fattened in the Valley.

Winters are comparatively mild. Feeding of hay and other harvested roughages to stock cattle is not customarily practiced, although necessary under certain conditions. Most of the local herds of breeding and stock cattle remain in the Valley throughout the year. Some, however, go to the foothills and mountains for summer grazing. The dry-land forage found in this area is nearly all of the annual type with the normal growing season in the winter and spring months. Bur clover is abundant on the richer soils in most years. Generally the forage reaches maturity in April and May. In midsummer after harvest some stock cattle are moved into grain stubble and continue on general field clean-up until the following grass season. Other cattle remain on dry range throughout the summer and fall. Animals on dry range and stubble often lose materially in weight unless provision is made for supplemental feeding. The acreage of seeded annual and perennial pastures on irrigable cultivated lands in this area is increasing.

San Joaquin Valley.—For many years beef cattle in the San Joaquin Valley were used almost entirely to market the grass crop from range and pasture lands. More recently they have been called upon to market products from the harvested crop lands of this very important farming region.

On a large acreage of alkaline lowlands the forage is composed of salt grasses, other perennials, and annuals. When situated on overflow or moist lands, such forage cover remains partially green throughout the summer. The forage on grazing lands at slightly higher elevation consists mainly of annual species that mature and dry in April and May. The volume and character of the range forage varies greatly according to

both rainfall and soil type. Heavy soils of some sections produce an abundance of bur clover. Such lands constitute some of the best ranges in the state for pasture-fattening of cattle.

The acreage of seeded pasture mixtures which are irrigated has rapidly increased during the past few years. These pastures vary in carrying capacity according to the character of the soil, the management practices, and the mixtures used. When properly managed, the better pastures carry from one to two mature animals per acre for a period of 7 to 8 months. Many different pasture mixtures are found, but Ladino clover and Dallis, Harding, orchard, and rye grasses are commonly used.

The Valley is one of the foremost cattle-producing areas of the state. Herds of various sizes are located in every section. The strictly range operator, the combination rangeman and farmer, the specialty feeder, and the farmer feeder, are all importantly involved in the beef-cattle picture. Some stockmen, who have dependable yearlong feed, breed and raise their cattle. Many operators maintain no breeding herds but purchase stockers and feeders annually. Still others follow a combination system of both breeding and purchasing stockers and feeders. Without exchange of ownership, there is considerable shifting of cattle around the Valley to utilize both range and crop-land grazing. A small percentage of the animals go into the high Sierras for summer range. Winters are mild and very little hay feeding of stock cattle is practiced. During the summer and fall months cattle grazing on dry range or grain stubble often experience a heavy loss in weight unless given supplementary feed. On bur clover ranges or on lowlands they may maintain weight during this period.

Although many cattle are bred and raised in the Valley, more stockers and feeders are shipped into this area than into any other part of the state. The bulk of such cattle originates in other southwestern states or in Mexico. Some come from the Sierra foothill area, other parts of California, and intermountain states. The demand for stockers and feeders is greatest in the fall and early winter months. The extent of demand for animals intended for further grazing is influenced greatly by the seasonal prospects for feed. Weaner calves and light yearlings comprise the greater part of in-shipments. Some operators ship in range cows which calve in the valley, the calves being sold as veal and the cows sold later.

There is now an increasing tendency among field-crop farmers to purchase feeder cattle for marketing home-grown feeds. Large feeding plants are located at numerous points. Some of the cattle fed in these yards are owned by packers. The greatest demand for feeder cattle by the farmer and specialty feeder usually occurs from August to Decem-

ber when harvested crops and their by-products are most abundant. Some feeder demand from these two sources continues on through the year. The farmers and specialty feeders purchase from both local and outside sources.

The San Joaquin Valley is not only one of the principal beef-cattle areas, but it also maintains over one third of the dairy cattle of the state. Marketings of slaughter cattle and calves from dairy herds are an important factor in the total tonnage of beef produced in this region.

With the many ramifications of production in this area, marketings of beef from the San Joaquin Valley are well distributed throughout the year.

South Coast.—In the coastal region, from San Francisco south, beef cattle are of major importance to the agriculture of San Benito, Monterey, San Luis Obispo, Santa Barbara, and San Diego counties and have a minor rôle in the other counties. This part of the state ranks along with the San Joaquin Valley in numbers of beef cattle. The primary function of beef cattle here is to utilize range lands, although in several important districts they are used to convert and market large amounts of hay, threshed grain, beet tops, and clean-up from crop lands. Most of the ranges are reasonably dependable for production of forage. The annual type of forage prevails, with some perennials found on protected ranges. The normal growing season is in the winter and spring months. At the lower altitudes and on south slopes, the principal range plants reach maturity and become dry in late April, May, or early June, except on the immediate coast where some forage remains partially green throughout most of the summer. At higher elevations in the coast range of mountains, the growing season is several weeks later than at the lower levels. In a few localities browse provides cattle feed, but dense brush which supplies no forage is a problem to many range-land owners.

Medium- and small-sized ranches predominate, but there are numerous extensive and specialized ranch units in this region, some of which represent old Spanish grants. Nearly all cattle are maintained on private land. Only a few operators depend on national forests or other public lands for grazing. While many cattle are bred and raised locally, the south coast area ranks second to the San Joaquin Valley in importations of stockers and feeders from other states. Most of these shipments occur in the fall and early winter months and come from both southwestern and intermountain states.

Seasonal marketings of cattle and calves vary from year to year, as determined largely by feed and market conditions. Most of the grass-fat steers, cows, heifers, and veal calves go to market in the period from late

April to early July. During July and August many steers and heifers that do not reach slaughter condition on range feed alone are fed concentrates while grazing on range, grain stubble, or shocked grain hay. Beet-top grazing is employed for finishing some cattle. These cattle move to market for slaughter during the fall months. In the late summer and fall some of the feeder cattle are placed in central feed yards located in the region. A lesser number are fattened in local farm feed lots. The bulk of the feed-lot cattle is marketed in the fall and winter months. Movement of stockers, feeders, and breeding cattle to and from the San Joaquin Valley is not uncommon. San Diego County cattle sometimes go into the Imperial Valley for fattening during the winter months.

Breeding herds and young growing cattle not intended for market may lose materially in weight during the fall months if left on range or ordinary stubble without any supplemental feeding.

In and near Los Angeles thousands of cattle are fattened annually in both private and custom feed yards. The number of cattle on feed in these yards varies greatly but is always an important factor in the feed-cattle market at Los Angeles. At times a substantial number of the cattle are owned by packers. These yards depend only to a minor extent on the south-coast area for cattle and feed; the cattle come from several states, and much of the feed comes from the Imperial and San Joaquin Valley farms and from industrial by-products. Feeding in this district is augmented by demand for fertilizer from citrus and truck-crop farmers.

North Coast.—Grazing, forest, and brush lands predominate in the north-coast area, extending from San Francisco north. The production of grains and hay is of minor importance except in Contra Costa and Alameda counties. In the counties adjacent to San Francisco, in Del Norte County, and in the Humboldt Bay district, dairy cattle are the principal animals used to consume local feeds. In most other parts sheep exceed both beef and dairy cattle in economic importance. Scattered throughout, however, are a few large herds of beef cattle, numerous medium-sized herds, and many small herds. Much of the land is rugged and mountainous. For the region as a whole rainfall is greater than in any other part of the state. In the higher altitudes of the northern portion, ranges are often covered with snow during the winter. Both annual and perennial grasses and browse are important as native forage on the range lands. In general the ranges are lacking in leguminous forage plants. Most of the grasses mature and dry in May and June but on the immediate coast and in some favored spots inland the forage remains partially green throughout the summer. In several sections marked im-

provement in grazing capacity of range lands through carefully controlled burning of worthless brush, and reseeding with desirable forage species has been fully demonstrated. On some range lands the competition between domestic livestock and deer for use of forage is significant and a problem to stockmen.

The beef cattle found here are nearly all bred and raised locally, although some stockers and feeders come each year from other states and other parts of California. The rather small number of grass-fat cattle are marketed principally in the period from early June through July. Only a limited number of ranchers follow the practice of fattening cattle on concentrates. Some feeder cattle go into central feed yards within the region for fattening. A few move into the Sacramento Valley to be finished for market.

Private and custom feed yards located in the San Francisco Bay region contribute significantly to the fed-cattle supply for Bay district slaughter. Cattle fed in these yards come largely from northern California and intermountain states. Much of the feed comes from the Sacramento and northern San Joaquin valleys and from local by-products of industry. These feed-yard operations depend only to a minor degree upon the north-coast area for cattle or feed. As at Los Angeles, some of the cattle are fed by packers.

Sierra Nevada Foothills.—The long narrow strip of country lying east of the Sacramento and San Joaquin valleys, on the west slope of the Sierra Nevada, is generally referred to as the Sierra foothill area. While variations are found in physical characteristics of the land, and in production practices, a general similarity is evidenced throughout the area.

Grazing is the principal agricultural use of the land except in the commercial fruit districts of the north-central portion. Income from beef cattle is the leading source of revenue for many ranches. A limited amount of native or cereal hay is grown, and in districts where irrigation water is available, numerous small irrigated pastures are found. Very little grain is produced. The native range forage is predominantly of the annual type. Browse, some perennial grasses, and a few legumes are found. At the lower elevations in the southern foothill region most of the forage except browse matures and dries in late March or April and slightly later in the northern part; at the higher elevations the forage matures in May and early June. Large areas of potential grazing land are occupied by brush which has very little forage value.

Nearly all the beef-cattle herds in the foothill area are small- or medium-sized, and are bred and raised locally. Many of the stockmen depend on the adjacent national forests for summer grazing. Some cattle

remain in the region throughout the year, while other herds may go into the lower valleys for seasonal grazing.

Marketings of cattle are fairly well distributed through the late spring, summer, and fall months. In favorable years veal calves, and some grass-fat cows, heifers, and steers move to market. The majority of the cattle are marketed in the feeder stage and go into other regions for fattening. There is very little finishing of cattle on concentrates within the region.

Local dry-range forage and hay are generally deficient in both protein and phosphorus during the last five months of the year. Many young cattle and breeding animals that remain on dry forage go into the winter thin in flesh unless supplements are used to correct prevailing feed deficiencies.

Imperial Valley.—Livestock is of steadily growing importance to the agriculture of Imperial Valley. All agriculture here is dependent on irrigation water from the Colorado River. The desert range surrounding the irrigated districts produces practically no forage. Livestock production therefore is confined to the irrigated lands. Vegetables, alfalfa hay, barley, grain sorghums, cotton, and flax are important cash crops, a large part of which are produced through specialty farming. Growers have depended mainly on the Los Angeles district as a market for their better grades of alfalfa hay. Much of the poorer-quality hay is fed locally and a large acreage of alfalfa is grazed annually by livestock.

Livestock numbers in the Imperial Valley have fluctuated widely, perhaps because of the specialized nature of its agriculture. Dairy and beef cattle are the principal classes of animals used to consume and market Valley crops. The relative importance of these two classes changes from year to year and at different seasons within each year. The shifts are largely because of the changes in beef-cattle numbers. On a yearlong basis dairy cattle have usually exceeded beef cattle. Most of the dairy herds are bred and raised locally. The number of beef-breeding herds maintained in the Valley is negligible. Nearly all of the beef cattle are brought in as stockers and feeders for seasonal grazing and fattening. In the past many of the beef animals have been owned by specialty-cattle operators who purchase feed from specialty-crop farmers. There now appears to be a trend toward diversification of enterprises on more Imperial Valley farms, involving definite crop rotations and greater dependence on beef cattle for marketing home-grown feeds.

Arizona, New Mexico, Texas, Utah, and Mexico contribute most of the stockers and feeders to the Imperial Valley. Nearly every class, age, and quality of cattle is represented through the many different shipments. In years past, older cattle predominated, but more recently yearlings

and weaner calves comprise an important part of the total. Heaviest importations occur in the fall and early winter, with late winter and spring shipments of light cattle into the Valley not uncommon. Beef cattle are used extensively for grazing the aftermath of general field-crop lands. The customary practice has been to depend primarily on alfalfa pasture to bring the cattle into condition for slaughter. Barley or some other grain is commonly seeded in alfalfa fields to improve pasturage. Dry alfalfa hay is usually fed in connection with alfalfa pasture.

Most of the mature cattle enter the Valley in the fall and move to slaughter four to six months later and before hot weather comes. Many of the calves and yearlings are held over the summer and for a complete year or more. The increased tendency toward yearlings and calves has resulted in the use of more concentrate feeds for fattening. Los Angeles is the market outlet for most of the slaughter cattle from this area.

Other Production Areas.—The areas previously described produce most of the beef cattle of the state but to the agriculture of several other areas beef animals are of significant importance.

The livestock use of the high Sierra country, including its eastern slope and interspersed mountain valleys, is chiefly for summer grazing of cattle and sheep that come in from home ranches located elsewhere. While most of the area is in national forests or other federal lands, much of the better mountain meadowland is privately owned. Where fenced and not overgrazed, the mountain meadows provide excellent summer grazing. Some yearlong cattle ranching units are located in the protected valleys where meadow hay is produced for winter feeding of stock cattle.

Certain parts of the vast desert area in the southeastern portion of the state provide good range forage for cattle. Perennial and annual grasses and browse predominate. The amount of desert forage varies greatly from year to year. Annual rainfall is always low in this area but desert forage plants respond surprisingly well if light rains occur at just the right time. The greatest limiting factor in utilizing desert range feed is the general lack of stock water. Although native desert range cattle will graze several miles from water, some good range feed goes unused because of its great distance from any water hole, spring, or well.

The Palo Verde Valley located in the eastern part of Riverside County along the Colorado River is similar in general characteristics of crop and livestock production to the Imperial Valley but much smaller in size. Grazing and fattening of cattle on feeds from irrigated lands is of growing importance in this valley.

The mountainous area located immediately south of the San Joaquin Valley and where the Sierra Nevada and Coast Range seem to meet is

sometimes referred to as the Tehachapi country. The chief crop of this section is range forage of both annual- and perennial-type species, except in the Antelope Valley where alfalfa for the Los Angeles market is the principal crop. Cattle ranges are rugged and are situated mostly at elevations from 3,000 to 6,000 feet. Snow and low temperatures are not uncommon in winter, and summer temperatures are high. Annual rainfall is extremely variable. A few large specialized cattle ranches and numerous small units are located in the Tehachapi area. Very little hay is produced; if cattle remain on the ranges through the winter, provision must be made for supplemental feed to avoid serious loss in weight of animals.

The rougher portion of the foothill area located west of the San Joaquin Valley is principally range land, while much of the more level acreage is devoted to grain farming. Annual-type forage prevails on the range. In favorable years the filaree crop is abundant and range feed is conducive to producing grass-fat cattle. Numerous medium- to large-sized beef cattle herds are found here, some of which are maintained within the area on a yearlong basis; others are brought in for seasonal grazing.

Much of the foothill area situated west of the Sacramento Valley is comprised of dense brush with interspersed open grazing land. Some grain and hay are produced in the little valleys within the area. Most of the locally owned herds are small in size. Some cattle from the Sacramento Valley come in for spring and summer grazing. A few grass-fat cattle are sold each year but the majority move out as feeders.

WEATHER DATA

Few phases of agriculture are as directly dependent on the elements of weather as the range-livestock enterprise. The amount of rainfall, when it occurs, and the accompanying temperatures largely determine the character and quality of range feed as well as its abundance. This is especially true where annual range forage plants predominate over perennials. The range forage in turn greatly controls the kind, class, and quality of livestock which can best utilize this feed. Finally, the weather decidedly influences the production and management practices to be employed with the animals concerned.

For these reasons, and to show some of the variations in weather that exist in California, long-time weather bureau records are presented in table 3.

TABLE 3
CALIFORNIA PRECIPITATION AND TEMPERATURES RECORDED AT U. S. WEATHER BUREAU STATIONS

Region and station	Elevation, feet	Precipitation						Temperatures					
		Years of records	Annual (inches)		Quarterly (per cent of total)				Average for Jan., °F.	Frost-free intervals (average)	Frost-free days (average)		
			Average total	High	Low	Jan., Feb., March	April, May, June	July, Aug., Sept.				Oct., Nov., Dec.	
Northeast:		21	12.0	18.4	6.8	34.3	23.9	11.3	30.5	27.4	67.2	June 14–August 31	78
Alturas.....		43	12.1	21.7	7.7	38.9	20.6	7.5	33.0	30.5	71.3	May 23–September 26	126
Cedarville.....		39	18.6	33.5	8.4	46.7	13.2	6.2	33.9	30.7	70.3	May 17–October 5	141
Susanville.....		49	12.4	21.2	3.8	35.4	16.9	10.4	37.4	34.5	74.7	May 14–October 1	140
Montague.....		62	36.8	62.3	14.6	48.5	14.7	2.6	34.3	45.3	82.0	March 1–December 4	278
Redding.....													
Sacramento Valley:													
Red Bluff.....		64	23.4	49.0	11.2	48.3	13.2	3.3	35.2	45.3	81.6	March 6–December 4	273
Colusa.....		58	15.9	31.3	7.5	55.2	9.6	2.8	32.5	45.0	77.4	February 26–November 22	269
Davis.....		51	16.1	31.7	7.0	56.1	9.7	2.1	32.0	46.7	76.4	March 17–November 14	242
Marysville.....		66	20.5	36.7	10.5	51.9	11.1	2.0	35.0	47.0	78.8	February 20–November 20	273
Sacramento.....		25	18.0	34.9	6.7	51.9	13.5	2.1	32.5	45.6	73.2	February 8–December 12	307
Vacaville.....		57	23.3	50.2	10.3	55.5	9.0	1.6	33.9	46.0	75.0	March 22–November 18	241
San Joaquin Valley:													
Stockton.....		66	13.8	26.4	6.4	53.8	12.0	2.4	31.9	45.7	73.5	February 13–November 28	288
Oakdale.....		215	13.7	28.2	6.5	54.4	12.1	1.8	31.8	44.6	77.8	March 24–November 19	240
Merced.....		173	11.4	23.8	4.3	55.4	12.6	2.0	29.9	45.9	80.4	March 6–November 20	259
Los Banos.....		120	8.5	16.7	2.9	55.1	13.2	1.7	30.0	48.5	80.0	February 10–November 27	290
Fresno.....		287	9.4	17.9	3.9	50.7	15.6	2.4	31.3	46.2	82.1	February 13–November 28	290
Visalia.....		334	9.5	19.6	5.1	53.5	15.3	2.5	28.7	45.7	80.5	March 8–November 27	264
Bakersfield.....		404	5.9	9.3	2.7	50.5	18.7	2.9	27.9	47.0	84.0	February 21–November 24	276

PRODUCTION COSTS

Since 1935 the Agricultural Extension Service of the University of California has coöperated with 87 cattle producers in 14 counties to study and analyze beef-production costs. Three distinct areas are involved in these studies: the northeast mountain area, the south coast, and the San Joaquin Valley. On most of these ranches sales of beef cattle represent the major source of revenue, with the cattle being used principally to market range and pasture feeds and harvested roughages. All of the ranches in the study maintain breeding herds of cows. A few of the operators purchase some stockers and feeders. On the average about 280 breeding cows and a total of about 730 animal units per ranch are represented in these studies. The project is not yet completed but has advanced far enough to warrant discussion of the following important factors in beef-production costs.

Capitalization.—Under existing conditions and where the beef enterprise must be charged with all the capital investment in a ranch unit, net returns have not justified a land and facility investment much in excess of \$125 per animal unit where the operator expects net earnings of 5 per cent. In the study the average investment in land and facilities per animal unit is shown to be \$161.66. The extremes range from \$90.76 to \$187.46. Where an interest rate of 5 per cent was figured on capital invested in range and pasture land, cattle, and facilities, the charge against invested capital accounted for 41.9 per cent of the sale value of all beef.

The danger of overcapitalization of the beef enterprise appears to be greater on specialty beef-cattle ranches than where beef-cattle production is merely a part of the general farming program.

Percentage Calf Crop.—The records show a direct correlation between percentage calf crop and net income on these ranches where the prevailing practice is to maintain breeding herds. Under present price and cost conditions, and with practices now employed, an average of 70 per cent calf crop appears to be necessary on these ranches to prevent financial loss. This percentage is based on number of breeding cows in the herd two years and over. The average percentage calf crop shown in the study is 71.6 per cent, with extremes from 50.6 to 95.2 per cent. The younger the animals are sold the greater the necessity of obtaining a high percentage calf crop.

Beef per Animal Unit.—In the study there is a direct relation between annual production of beef per animal unit and the net returns. The average annual production for the ranches studied has been 291 pounds per

animal unit with extremes from 116 to 482 pounds. The amount of production per animal is closely associated with percentage of calf crop and age of marketing. About 285 pounds of beef per animal unit, under prevailing price and cost conditions, is required for these ranches to pay total operating expenses of the cattle enterprise.

Age of Marketing.—Where these operators breed and raise their cattle, the studies point out that the greatest net income per animal unit is obtained when market animals are sold between the weaning and two-year-old stages. An analysis of the records indicates that the optimum point for selling within these age limits depends mainly on percentage of calf crop, weight for age, and the quality of cattle.

General Management.—The studies emphasize the need for analyzing each ranch unit separately to find the best methods for applying fundamental principles of management. They also show that certain production and marketing practices proved to be efficient for one ranch may not be applicable to another.

As a group, the ranch operators showing greatest net returns above all costs invested more time and money in systematic and careful breeding, feeding, and culling practices, than did the low-income group.

THE DRESSED PRODUCT

An understanding of the factors that influence the quality of dressed beef is valuable to producers in planning production programs.

Meat is the nucleus around which well-balanced meals are planned. The value and place of meat in the human diet may be summarized as follows:

1. Meats are rich in proteins having high biological and supplementary value for cereal and other vegetable proteins. The average serving provides more protein than any other article in the diet.

2. The average serving of meat ranks high among other foods as a source of energy.

3. Meats rank at the top of the list of foods in amount of phosphorus, iron, and copper, but are low in calcium. Liver contains substances other than copper and iron that are valuable for relieving anemia.

4. Lean meat contains liberal amounts of vitamins B, G, and pellagra-preventing nicotinic acid. Fresh lean meat contains enough vitamin C to prevent scurvy. Liver is a rich source of vitamin A and supplies all known vitamins.

5. Meat is 95 to 98 per cent digestible and contains nitrogenous extractives that stimulate appetite and digestion and that contribute to the flavor of meat and hence to the pleasure of eating.

Beef is more variable than pork or lamb because of the greater difference in age and condition at which the animals are marketed. There is also more difference in tenderness of various parts of the beef carcass. Demands of different classes of consumers vary. Some of the things that the consumer considers in buying beef are: proportion of meat to bone, relation of lean to fat, distribution of fat and lean, color and texture of fat, lean, and bone. To the average consumer *tenderness* is the first consideration in satisfaction of eating, and *flavor* ranks second. Breeding, feeding, age, sex, methods of slaughtering, curing and ripening, and manner of cooking all influence the desirability of the product.

Tenderness.—The degree of tenderness of beef depends on the amount of connective tissue it contains. Tenderness decreases with age and presumably with exercise. The muscle-fiber bundles in calves are small, giving fine texture, while in mature animals they are larger and the surrounding connective tissue becomes thicker, producing coarser “grain.” Deposition of fat in and between these connective tissues disperses them and increases tenderness. To attain the same degree of tenderness, older animals must be fattened more than younger ones. There are two types of connective tissue, yellow and white. When cooked with moist heat white connective tissue changes to gelatin, and thus increases tenderness. Supporting muscles such as the back and loin are more tender than the muscles of locomotion. The retailer separates the cuts on this general basis. The more tender cuts are used for steaks, chops, and roasts that are cooked with dry heat. The less tender cuts are made tender by moist heat such as boiling or pot-roasting. Enzyme action that occurs in the tissues while aging in the cooler increases tenderness and improves flavor. The extent to which beef can be aged depends largely on the degree of fatness; fat protects the surface of the carcass from molds and from bacterial action.

Flavor.—Beef flavor is affected by age, sex, finish, aging or curing, cooking, and seasoning. Intensity of flavor increases with age from veal to mature beef. Flavor is affected by fat, particularly that interspersed with the lean (marbling). The flavor of the lean is due in large measure to the meat extractives (the water-soluble materials that are found in broth). Feeds apparently play only a very minor rôle in beef flavor except to the extent that they govern degree of fatness. The juiciness of beef is important in flavor. Well-finished beef will remain juicy and hence better flavored than poorly finished beef that may “water off” not only in cooking but in the butchers’ trays as well. This “watering off” is apparently dependent on whether the fluid is “bound” or is free in the tissues. Though this may be influenced by feed and degree of finish, the

exact relations are not understood. Fat prevents excessive drying of cooked beef.

Color of the Lean.—The color of lean beef is due primarily to muscle hemoglobin (iron containing red coloring matter), but the brightness is modified by the amount of fat and its distribution in the lean. Muscle hemoglobin increases with age and presumably with exercise. Veal is very light; meat from bulls and aged cows is dark. The amount of muscle hemoglobin bears no relation to the hemoglobin in the blood. Although there is some evidence that exercise affects color of the lean, it apparently is a minor factor under practical conditions. The Illinois Agricultural Experiment Station reports that exercise equivalent to traveling more than 7 miles daily during fattening failed to change the color of lean materially. Grass-fed cattle are commonly thought to kill darker than feed-lot cattle. Experiments at the Virginia Station, however, revealed no difference when grass-fed and feed-lot cattle had equal finish. Similarly no practical difference was found in trials at the Kansas Station, although delicate analyses revealed slightly more muscle hemoglobin in pasture-fed cattle.

The freshly cut surface of beef is dark, similar to venous blood. Upon exposure to air it brightens to resemble arterial blood. This brightening is rapid for 30 minutes and continues for as much as 3 hours. After this time it may darken again permanently owing to decomposition of the hemoglobin.

In some carcasses the cut surface of the "eye of beef" or other muscles fails to brighten and may be almost black. This condition is known in the trade as "dark" or "black cutters." It may occur even in young, well-bred and well-finished animals. It is commonly said to be caused by overheating, excitement, and exercise before slaughtering, or by improper bleeding. Tests of these factors, however, under experimental conditions and of numerous kinds of feeds have failed to produce dark cutters. Some condition or substance in the tissues prevents the muscle hemoglobin from absorbing oxygen and turning bright red in color. Thus far no satisfactory explanation has been definitely established. Heredity may be involved. Since dark cutters sell for less money, they are a problem of importance to the packer. The cooked meat, however, is just as palatable and desirable as beef of normal color.

Color of the Fat.—Yellow color of beef fat is caused by deposition of carotene, the precursor of vitamin A. Carotene cannot be formed in the animal body; it must be obtained from plant sources. It is present in all green plant tissue and in yellow roots.

The amount of carotene in the fat of cattle depends on: (a) the caro-

tene content of the feed, (b) hereditary variation in different animals that limits its storage, and (c) storage as affected by the age of the animal. Green pasture is rich in carotene and hence tends to produce the most color in beef fat. Even the best-cured hays have lost a high percentage of this constituent; thus they have less tendency to produce yellow fat. Grains, oil meals, and other concentrates are all low in carotene. The meat trade frequently associates yellow color with "cake"-fed cattle. Cottonseed cake contains no carotene, and a ration of cottonseed cake and hulls produces white fat. Cake-fed cattle frequently are "warmed up" on grass or fed for a short time on dry forage, and they commonly retain the yellow color accumulated during the green-feed season.

The calf at birth contains no carotene regardless of the feed of the mother. Storage increases with age so that under the same feed conditions yearlings have less fat color than two-year-olds and they in turn less than mature cattle. On the same feeds, Jersey and Guernsey cattle store more carotene in their fat tissues and secrete more in their milk than Holstein or beef breeds. The latter change more of the carotene to colorless vitamin A. Individual variations with respect to fat color occur within breeds.

Old cows and grass-fed cattle that frequently are not well finished are most likely to have yellow fat. Hence, this color has come to be looked upon as an indicator of poor quality and there is prejudice against it, although it is the same color that is highly prized in cream and butter. The carcasses of young well-finished cattle may be yellow if the animals have had feeds high in carotene. On the other hand, dairy cattle fed exclusively on feeds lacking in carotene have white fat. Yellow color is therefore not a reliable index of quality. Yellow fat, though often coincidental with lower grades, is not necessarily associated with soft fat or any other factor concerned with the desirability of the meat. In recognition of these facts, color should be minimized as a factor in beef grading. The prejudice, however, is well fixed and difficult to overcome.

Discrimination against yellow color may be unfortunate to both consumers and producers, as the latter can often economically produce high-quality beef in other respects by utilization of pasture and forages cured to retain highest nutritive value.

Fattening.—Fattening occurs in three overlapping phases: first, around the kidneys and internal organs; second, over the surface of the muscles; and third, in the lean tissues. Cattle poorly bred for beef cannot readily or economically be brought to the final stage. They tend to become wasteful in internal and external fat without distributing it evenly over the body and through the lean. The tendency for marbling

and fine texture of lean is hereditary. Fattening increases yield, tenderness, flavor, and to a slight extent the proportion of hindquarter to forequarter. Adequate finish protects the carcass in the cooler which permits aging. It increases juiciness and decreases moisture loss in cooking. Excessive fat does not increase desirability of flavor; it is uneconomical to produce and largely goes into garbage.

Some of the principal results of cooperative investigations between experiment stations and the National Livestock and Meat Board on quality and palatability of beef are summarized as follows:

No important differences were found in quality or palatability of meat from different beef breeds. The chief differences between meat from cattle of improved and unimproved breeding, fed similarly, were found to be in weight for age, in yield, and in appearance of the carcasses. Heifer and steer beef were found equal in palatability.

Various practical balanced rations comparing such feeds as corn with wheat, cottonseed meal with linseed meal, and hay with silage, have not, in general, produced significant differences in the palatability of the resultant beef. Beef from three-year-old steers fed 8 pounds of grain daily on good pasture was fatter and more attractive but only slightly more palatable than the beef from steers fed on good pasture alone. It has appeared that the color, tenderness, and desirability of lean in cattle depend more upon other factors than upon the amount and character of the grass or grasses that the animal has eaten.

Heifer beef proved definitely more tender than beef from cows five years old or over, although there were no marked differences between them in desirability of flavor or in juiciness. On the other hand, roasts from fattened two-year-old and yearling steers, though more palatable in general than roasts from fattened calves, showed no significant differences in tenderness. Distribution of fat through the lean was more satisfactory in beef from yearling and two-year-old cattle than in that from calves. Age of the animal had little influence on the percentage of the various cuts of beef among fattened calves, yearlings, and two-year-olds.

Richness of juice appeared to improve somewhat with increasing finish, although a highly desirable richness of juice does not require excessive finish.

Creep-feeding of calves previous to weaning increased the fatness, dressing percentage, storage quality, and attractiveness of the resultant beef.

Steers that had lost weight on drought-stricken pasture produced meat containing a most undesirable flavor and odor according to the results secured in one trial.

Producers can control or influence the quality and desirability of the beef by :

1. Breeding and selecting for thick-muscle, early-maturing cattle, that fatten readily and distribute the fat evenly.
2. Feeding to promote continuous growth.
3. Fattening at an early age or to a degree adequate for particular classes, grades, and ages of cattle.
4. Dehorning at the proper time and careful handling of cattle to prevent injuries and bruises in shipment to market.

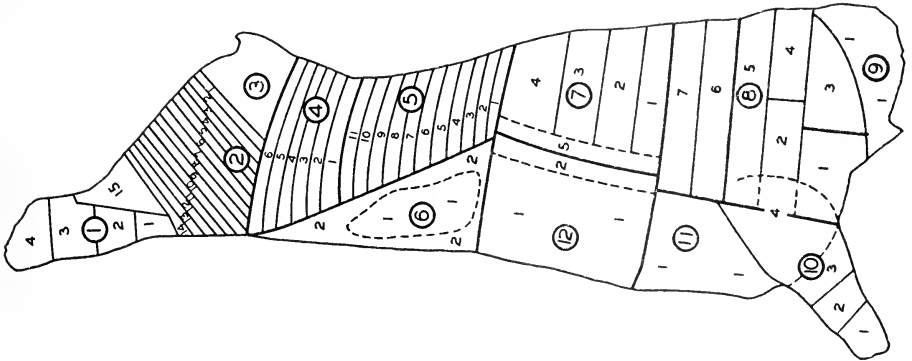


Fig. 9.—Wholesale and retail cuts of beef carcass. For identification of cuts see the following tabulation. (Chart prepared by U. S. Dept. Agr. Bur. Agr. Econ., Division of Livestock, Meats and Wool.)

Beef Cuts and Their Uses.—Figure 9 shows the location of wholesale and retail cuts to be found in the beef carcass. The identification of each cut, its approximate percentage of the carcass weight, and its principal uses are shown in the following tabulation :

Wholesale cuts	Percentage of carcass	Retail cuts and principal uses
1. Hind shank	4.0	1 to 3, soup bones; 4, hock.
2. Round	15.0	1 to 14, round steaks; 15, heel for pot roast or corning.
3. Rump	5.0	Steaks or roasts.
4. Loin end	7.0	1 to 6, sirloin steaks.
5. Short loin	13.5	1 to 3, club or Delmonico steaks; 4 to 11, Porterhouse steaks. (Kidney knob, 3 per cent, included with short loin.)
6. Flank	3.5	1 flank steak; 2, stews or hamburger.
7. Rib	9.5	1 to 4, rib roasts; 5, short ribs.
8. Trimmed chuck	17.0	1 and 2, bottom chuck pot roasts; 3 and 4, top chuck pot roasts; 5 to 7, chuck rib roasts and pot roasts.
9. Neck	5.0	1, boneless pot roasts, stews, or hamburger.
10. Fore shank	5.5	1 to 3, soup bones; 4, shoulder clod (small pot roast).
11. Brisket	6.5	1, stews, boiling meat, or corned beef.
12. Plate	8.5	1, stews, boiling meat, corned beef; 2, short ribs.

NUTRIENT REQUIREMENTS AND CATTLE FEEDS

DRY MATTER AND TOTAL DIGESTIBLE NUTRIENT REQUIREMENTS

Cattle generally can consume about 3 pounds daily of dry feed or its equivalent for each 100 pounds live weight. This figure is convenient for roughly estimating feed capacity, although the amount may vary from 2.0 to 3.25 pounds. Feeds vary widely in digestibility. A full feed of poor-quality roughage may not furnish more than maintenance, while a like amount of good-quality roughage will produce moderate gains. Excellent-quality pasture or harvested roughage will promote normal growth of young animals. A combination of good roughage with liberal amounts of concentrates is necessary to supply sufficient digestible nutrients to fatten rapidly growing cattle. More accurate expression of both protein and digestible-nutrient requirements is given in table 4.

PROTEIN REQUIREMENTS

Proteins are nutrients that serve the special function of furnishing the material for growth and repair of muscle, nerve, glandular tissue, hair, skin, horns, and hoofs. Deficiency of protein often occurs in feeds and limits growth, fattening, reproduction, and lactation. The protein requirements may be expressed in different ways. The most accurate ways are in pounds of *digestible* protein according to the weight of the animal, or the ratio of digestible protein to the remainder of the total digestible nutrients in the feed (nutritive ratio), as shown in table 4. Because of

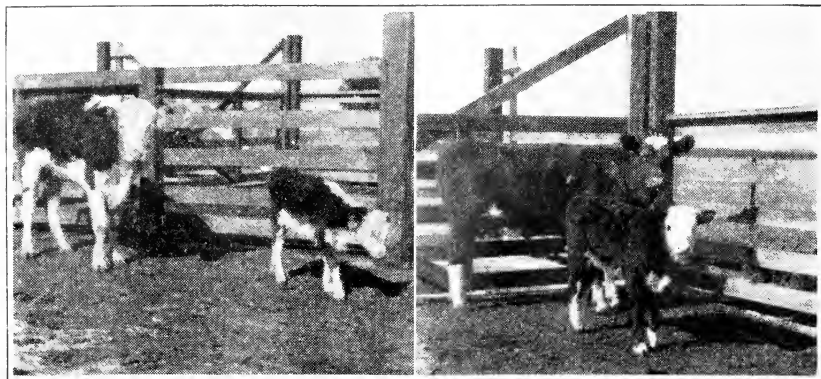


Fig. 10.—The cow on the left received a ration low in protein and phosphorus, similar in composition to that of dry grass-filaree range forage. The cow was thin and weak, and she produced little milk for her undersized calf. The cow on the right received the same ration plus 2 pounds daily of cottonseed meal. She maintained thrifty condition and produced abundant milk and a growthy calf.

TABLE 4
AVERAGE DIGESTIBLE-NUTRIENT REQUIREMENTS PER HEAD DAILY*

Class of cattle and weights of animals, pounds	Total dry matter, pounds	Digestible protein, pounds	Total digestible nutrients, pounds	Nutritive ratio
For moderate growth				
Calves:				
300.....	8.3	0.6	4.6	1:6.6
400.....	10.3	0.7	5.7	1:7.1
500.....	12.1	0.8	6.7	1:7.4
Yearlings:				
600.....	13.3	0.8	7.2	1:8.0
700.....	14.8	0.8	8.0	1:9.0
For rapid growth				
Calves:				
300.....	8.6	0.8	5.9	1:6.4
400.....	10.9	1.0	7.2	1:6.4
500.....	13.0	1.1	8.5	1:6.7
600.....	15.0	1.2	9.6	1:7.0
Yearlings:				
600.....	15.0	1.2	9.6	1:7.0
700.....	17.1	1.2	10.7	1:7.9
800.....	19.1	1.3	11.8	1:8.0
For fattening				
Calves:				
400.....	12.7	1.2	9.8	1:7.0
500.....	14.5	1.4	11.4	1:7.0
600.....	16.1	1.6	12.9	1:7.0
700.....	17.5	1.8	14.2	1:7.0
800.....	18.7	1.9	15.2	1:7.0
Yearlings:				
600.....	16.3	1.4	12.7	1:8.0
700.....	18.3	1.6	14.4	1:8.0
800.....	20.3	1.8	16.1	1:8.0
1,000.....	22.9	2.1	18.5	1:8.0
Two-year-olds:				
900.....	22.3	1.8	17.4	1:8.5
1,000.....	23.5	2.0	18.8	1:8.5
1,100.....	24.1	2.1	19.6	1:8.5
For pregnant cows, normal development				
Cows:				
900.....	18.4	0.6	9.7	1:15.0
1,100.....	21.5	0.7	11.3	1:15.0

* Taken by special permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding*, 20th Edition, by F. B. Morrison.

wide variation in digestibility of feeds, percentage of total protein in the ration is a less accurate means of expressing requirements, but may be useful when digestibility is not known. Rations for rapid growth and fattening should contain from 10 to 12 per cent *total* protein. Good-quality roughages containing 7 to 8 per cent *total* protein will meet requirements for mature pregnant cows and other mature cattle, but are deficient for growing animals. Less than 8 per cent protein in poor roughage and dry range forage of low digestibility is definitely deficient for all classes of cattle. When the protein of such feeds is below this level, losses in weight usually occur (fig. 10).

MINERALS

Common salt, calcium, phosphorus, and iodine are the only minerals upon which there is definite evidence of deficiency occurring in California. Fluorine is sometimes present in excess in waters from hot springs and causes loosening and mottling of teeth and bone disorders. In the light of present knowledge, the use of complicated and expensive mineral mixtures is not justified.

Salt.—Cattle usually are allowed free access to salt. Although the amount consumed varies with the character of the feed, 1 to 2 pounds per month is a common provision for range cattle. Very little salt is consumed by cattle grazing on salt grass. The consumption of salt by cattle often exceeds their normal requirements. Experiments have shown that excessive quantities of salt are taken by cattle on poor range feed and on other rations low in protein and phosphorus. This indicates that salt consumption may be a manifestation of hunger and abnormal appetite caused by other deficiencies. In numerous experiments, no measurable effect on cattle has resulted from feeding sulfur or sulfurized salt.

Calcium and Phosphorus.—Over 90 per cent of the ash of the animal body consists of calcium and phosphorus. Approximately 99 per cent of the calcium and 80 per cent of the phosphorus of the body are present in the bones and teeth. These elements also have important functions in numerous body processes. Either calcium or phosphorus deficiency over a long period results in abnormalities of the skeleton, such as rickets in young animals and osteomalacia in older animals. There is no evidence that these deficiencies cause abortion. A high amount of calcium with low phosphorus is unfavorable to phosphorus utilization and intensifies deficiency.

Phosphorus deficiency, especially, causes bone, wood, and dirt eating, loss of appetite, poor feed utilization, emaciation, and finally results in stiffness of joints, or even fracture of bones. Mild phosphorus deficiency

may stop the regular occurrence of "heat" periods. Such conditions have occasionally been reported locally in various parts of California. About 0.2 per cent of phosphorus in the dry matter of feeds for young growing cattle appears to be the lower limit for optimum growth of normal bone. The requirement decreases with maturity, so that about 0.12 per cent of phosphorus in the dry matter suffices for mature cattle if conditions are favorable for its utilization. Cows nursing calves require about the same percentage of phosphorus in the ration as young growing animals. The effect of phosphorus deficiency under experimental conditions is shown in figure 11.

The phosphorus and protein content of most feeds is highly correlated. Dry range feeds such as annual grasses and filaree are low in both. The protein deficiency is frequently more acute than that of phosphorus and affects the animals more quickly. Too much reliance should not be placed upon phosphorus supplements when the range feed is predominantly dry annual grass and filaree. Though experiments show that adequate phosphorus increases the utilization of protein, and that even on low-protein rations animals do better when phosphorus is adequate, the low protein under these conditions is still a limiting factor for efficient use of the forage. Protein supplements such as cottonseed meal are relatively high in phosphorus, and phosphorus needs will automatically be met when sufficient supplement is fed to meet protein requirements. Ordinary feed-lot rations containing grains are adequate in phosphorus. A heavy ration of beet pulp and molasses with a moderate amount of alfalfa hay is deficient in phosphorus.

The calcium requirement is about twice that of phosphorus. Grains, seeds, and oil meals are very low in calcium, while green pastures and most roughages are well supplied. Legumes are rich in calcium compared with grasses and other nonlegume forage. Except when calves are heavily fed on concentrates with small amounts of nonlegume roughage, calcium deficiency is rare in cattle. Although dry wild oats and other range grasses may be comparatively low, calcium deficiency on the range is unlikely because of the prevalence of high-calcium forage such as filaree, legumes, and browse (tables 5 and 6).

Mixtures of 40 to 60 per cent of sterilized bone meal or bone black with salt are recommended as cheap phosphorus supplements that also furnish plenty of calcium. In order for a supplement to be effective when supplied as a lick on the range, frequent consumption by cattle is essential. It should, therefore, be supplied in boxes, troughs, or salt logs distributed at convenient places over the range where the cattle will be tempted to take some daily.

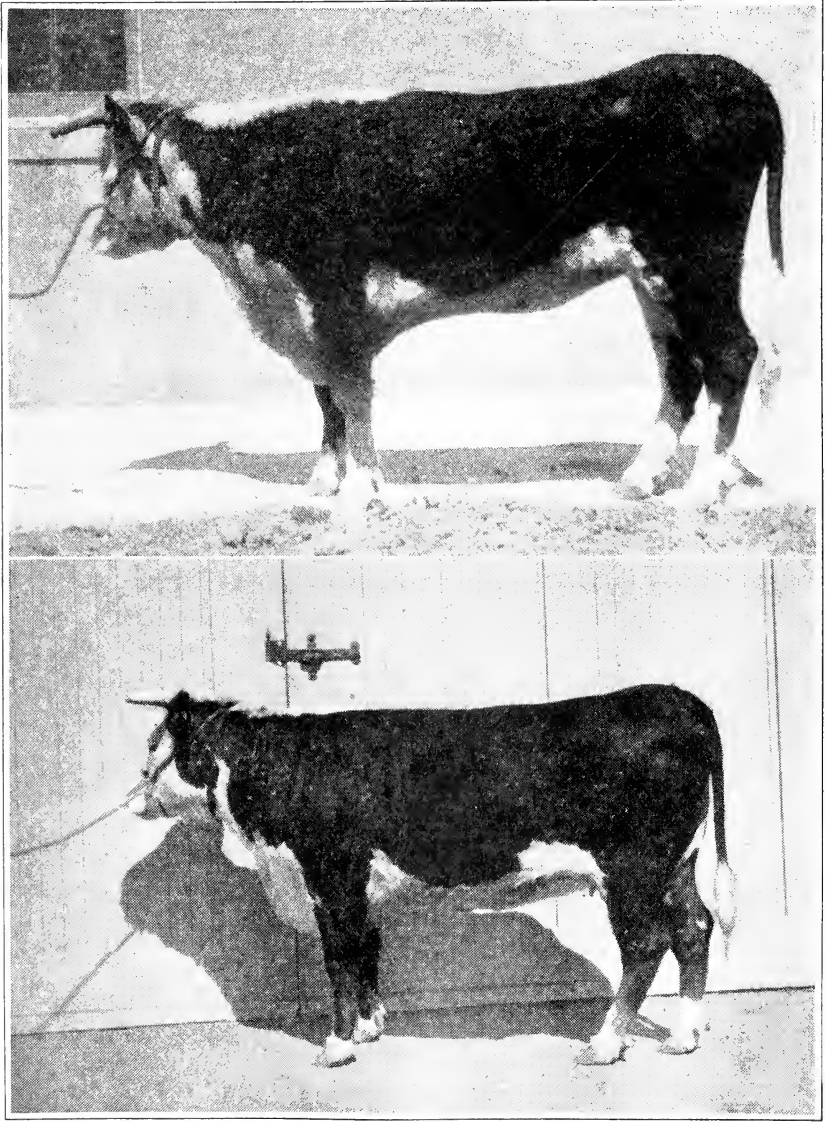


Fig. 11.—The heifer in the upper picture gained for a six-month period on a ration containing 0.13 per cent phosphorus. She maintained weight for a year on a ration containing 0.09 per cent phosphorus, but lost weight during a six-month period when the ration contained only 0.07 per cent phosphorus. Her appetite was poor and depraved, her blood phosphorus low, and she had no heat period for more than a year. The control animal shown below received ample phosphorus supplement. She continued to gain, was thrifty, and had regular heat periods. The photographs were taken at the close of the experiment.

Iodine.—Iodine deficiency is manifested primarily in the birth of weak or dead calves having enlargement of the thyroid glands which are located in the neck. Areas in which iodine content of feed and water is deficient are localized. The whole lava country of northeast California is considered a borderline goiter area with certain sharply defined localities definitely deficient. Even within these areas, there appears to be seasonal variation in occurrence of goiter. Some areas in the heavy-rainfall district of the north-coast section are also deficient. In deficient areas losses of calves occur unless iodine is supplied. Thin, small calves from cows in good condition may possibly be a manifestation of mild deficiency even though enlarged glands are not observed.

Iodized block salt has not thus far been a satisfactory means of supplying iodine. Iron compounds commonly used in block salt to give a color resembling the popular conception of iodine, activate the decomposition of potassium iodide and liberate free iodine which then evaporates. Potassium iodide salt is white. Some salt blocks have been found to lose almost all the added iodine within a short time, especially when exposed to sun and moisture. Improvements have been made in recent years, but in those tested, the iodine is nearly always gone from the outside layers licked by the animals unless more than the usual depth is removed daily.

The cheapest way to insure an iodine supply to cattle is to purchase potassium iodide and mix it with salt as needed. One ounce of potassium iodide to 300 pounds of fine-ground salt gives a mixture containing approximately 0.02 per cent. Two or three times this amount may be used to insure a plentiful supply. Large excesses are detrimental. The potassium iodide should be finely ground, mixed thoroughly with a small amount of salt, and then mixed with the remainder of the salt. Lamp black can be used as a "tracer" to show when thorough mixing is accomplished. A freshly prepared mixture should be supplied at frequent intervals. Protection of the salt boxes from direct sunlight and rain is desirable.

The extra cost of using iodized salt is not justified in areas in which deficiency is unknown, particularly since in many cases the animal may not get appreciable amounts of the iodine. Stockmen have in some cases reported that cattle show a preference for the iodized block salt; such preference may not be due to the iodine content of the salt.

VITAMIN REQUIREMENTS

Vitamins A and D are the only ones definitely known to be required by cattle. Since vitamin D, which is essential to utilization of calcium and phosphorus, is present in sun-cured feeds and is developed in the animal

body when exposed to direct sunlight, deficiency of this factor under California conditions is improbable.

Vitamin A.—Carotene, a yellow pigment found in all green plant tissues, is the primary source of vitamin A. This is the yellow coloring matter of carrots and of milk and body fat of cattle. Carotene may be changed in the animal body to colorless vitamin A, identical with that found in fish-liver oils. In cattle most of the storage accumulating under favorable conditions is found in the liver as preformed vitamin A. Significant amounts of unchanged carotene are stored particularly in the body fat.

Carotene decomposes rapidly under exposure to sun and air. Consequently dry range forage, bleached hays, and straw are lacking or contain only traces of this essential substance. Since grains and other concentrate feeds, with the exception of yellow corn, are deficient in carotene, cattle must either have some green feed in the ration or exist upon reserves stored in the liver and fat tissues. If the period on deficient feeds is prolonged, reserves are depleted and deficiency symptoms develop.

Vitamin A or carotene is essential for normal vision in dim light, for normal functioning of nerves, and for other tissues such as the skin and mucous membranes. Deficiency of vitamin A or carotene results first in night blindness and later staggering gait, convulsions, total blindness, clouding of the corneas of the eyes, loss of appetite, and finally death. Local paralyses frequently occur. Even mild deficiency results in birth of weak or dead calves.

The vitamin-A requirement is directly proportional to body weight. The amount of carotene necessary to maintain normal growth and freedom from symptoms of deficiency is about 1.5 milligrams for each 100 pounds live weight. About 0.25 milligram or 1,000 U.S.P. units of preformed vitamin A for each 100 pounds weight suffices. For cows whose reserves have been depleted, three to five times these minimal amounts must be supplied to assure birth of normal calves and to produce sufficient in the milk for normal growth.⁵ Experiments at the California Agricultural Experiment Station have shown that much larger amounts are necessary to produce milk of highest vitamin-A value. Good green hay and pasture furnish enough for all requirements and an excess for storage.

Further information on storage relations and requirements and recommendations to prevent deficiency will be found in the third part of

⁵ A more complete discussion of vitamin-A deficiency in relation to reproduction will be found in: Hart, G. H., and H. R. Guilbert. Vitamin-A deficiency as related to reproduction in range cattle. California Agr. Exp. Sta. Bul. 560:1-30. 1933.

this circular, "Production of Feeder Cattle." The relation of carotene to color of fat is discussed at the end of the first part.

Other Vitamins.—Vitamins of the water-soluble "B complex" may be produced in the rumen of cattle by bacterial action. Deficiency of these factors in cattle has not thus far been demonstrated or recognized. Vitamin C is synthesized by cattle and is, therefore, not required in feeds. Vitamin E is essential to reproduction in rats and for fertility and hatchability of eggs. Whether or not cattle require this factor has not been experimentally demonstrated. This vitamin is widely distributed in cattle feeds. Wheat-germ oil is a rich source of vitamin E and extravagant claims are sometimes made regarding its value for reproductive difficulties in cattle. Most of the troubles of this kind have other known causes.

WATER REQUIREMENT

Too little attention is frequently given to adequate supply of water. No deficiency of an essential substance is felt more quickly than lack of water. It is an integral part of all active tissues and a plentiful supply is essential to rumination. When rumination is interfered with, all digestive processes are impaired and food consumption decreases or stops. Water requirement varies greatly with the nature of the feed and its moisture content as well as with weather conditions. Ordinarily 10 gallons daily may be used in figuring water provisions necessary for mature cattle. Twice this amount, however, may be consumed by mature cattle pasturing beet tops. Water consumption also increases with the amount of milk produced. Excessive quantities of dissolved salts in stock water is sometimes a serious problem. The kind of salts dissolved appears to be a minor matter as compared with the total amount present. The upper limit of tolerance for cattle according to the Oklahoma Agricultural Experiment Station is 1.5 per cent total dissolved salts.

CHARACTERISTICS OF RANGE FORAGE^a

Annual Forage Plants.—The principal forage plants of California foothill and valley ranges are annuals that germinate after the first autumn rains. They make varied amounts of growth during the winter according to temperature and moisture conditions. From February to May is usually the period of greatest forage production. The relative abundance of different species varies with soil, seasonal distribution of rainfall, and closeness of grazing.

^a Unless otherwise indicated, data in this section are from: Hart, G. H., H. R. Guilbert, and H. Goss. Seasonal changes in chemical composition of range forage and their relation to nutrition of animals. California Agr. Exp. Sta. Bul. 543:1-62. 1932. (Out of print.)

In general the various forage species are, in the early stages of growth, high in water, protein, and minerals, and low in crude fiber. The dry matter of actively growing plants is much more digestible than that of the leaves and stems of the same plants in the mature stage and has the characteristics of a concentrate feed rich in protein. The high moisture content in the early stages, coupled with the animal's difficulty in obtaining sufficient quantity, limits gains during this period. The various species of forage plants differ markedly in composition and nutritive value when mature and dry. Since the botanical composition of range forage may vary greatly from year to year, knowledge of chemical characteristics of the principal types of plants is valuable in judging the quality of the feed and in selecting suitable supplements. These annuals may be broadly classified as flowering herbs, grasses, and legumes.

Of the flowering herbs or broad-leafed plants, the filarees (*Erodium* spp.) are most important and may frequently constitute more than 50 per cent of the total forage. In some areas other flowering plants may contribute significantly to the forage taken by cattle for limited periods.

Three species of filaree are widely distributed in California. Red-stem filaree (*Erodium cicutarium*) is found generally over the more fertile valley and foothill ranges. White-stem filaree (*Erodium moschatum*) is often found intermixed with the red-stem, especially in the coastal areas, and it appears frequently in old cultivated fields. These species, along with annual grasses, produce during the growing season, very nutritious pasture. The broad-leaf species (*Erodium Botrys*) predominates, or may be found exclusively on the poorer granitic, red, gravelly, or other soil in the oak and digger pine belt of foothill areas. Livestock prefers the red-stem and white-stem to the coarser broad-leaf species. These are higher in protein and minerals and lower in fiber at comparable stages of growth than broad-leaf filaree and, under the same soil and moisture conditions, tend to remain green somewhat later in the season.

The filarees are high in calcium and total soluble minerals. The dry matter in the early stages of growth is rich in protein but after maturity the amount is ordinarily too low to meet the requirements of cattle. Dry filaree is low in phosphorus, and the wide ratio of calcium to phosphorus is unfavorable to phosphorus utilization. The fiber increases with maturity and drying so that total feed value becomes a limiting factor in producing gains. After long periods on dry feed the feces of cattle that are eating considerable quantities of filaree and other plants high in soluble minerals remain moist and soft, whereas the droppings of cattle, grazing exclusively on dry grasses that are low in ash, tend to become hard and dry.

A large number of species of annual grasses are widely distributed on California ranges. Wild oats (*Avena* spp.), bromes, fescues (*Festuca* spp.), and foxtail predominate. Wild oats and foxtail (*Hordeum murinum*) are generally abundant under good soil and moisture conditions, while bromes and fescues predominate in poorer soils. Closeness of grazing may also affect the relative abundance of different species. Under light grazing, or complete protection, taller-growing species such as wild oats and often such objectionable species as rigput or needle brome (*Bromus rigidus*) flourish to the exclusion of shorter, finer grasses, filaree, and legumes.

Most of the grass species are palatable and nutritious in the early stages of growth, but become deficient in protein and low in energy value at maturity. The available calcium and the total mineral content of dry grasses are low in contrast to those of filarees and clovers. Phosphorus content is also low, as with filaree. The seeds of most species scatter quickly when matured and become relatively unavailable for grazing. Some seeds no doubt are obtained through grazing along with the fine leaf material on the ground. Seeds are relatively higher in phosphorus and the abundance of seed crop may increase the supply of this essential nutrient. Soft chess (*Bromus mollis*), probably the most desirable of the annual brome-grass species, retains the seeds in the seed heads for considerable time, and these are grazed by cattle before the less nutritious stems are eaten. The seeds of foxtail and needle or rigput brome, through mechanical injury to eyes and mouth, cause significant damage. The fiber content of grasses tends to be higher than in the red- and white-stem filaree and clovers and of a tougher nature. Because of high fiber and low digestibility of the dry, mature grasses, the amounts that can be consumed by cattle furnish little more than the energy requirement for maintenance even when protein and mineral deficiencies are corrected by supplemental feeding.

Legumes contain more protein than grasses and flowering herbs. Bur clover (*Medicago hispida*) is an outstanding species that maintains relatively high nutritive value even in the mature dry state. The protein content may exceed 30 per cent of the dry matter in the early stages of growth. The amount decreases with maturity, but mature dry bur clover averages about 15 per cent protein, an amount more than necessary to meet minimum requirements of cattle. It is, therefore, a valuable supplement to other forage low in protein. The calcium and phosphorus content is adequate to meet nutritional requirements. Digestibility is relatively high and gains continue when cattle have dry feed containing abundant bur clover. It is found on the richer heavier soils, and early

fall rains accompanied by warm weather make favorable "bur-clover years." The seeds and pods have about the same chemical composition as the combined stems and leaves. Many seeds are impervious to moisture and pass through the digestive tract of animals apparently unchanged. The availability of the seeds of this species for grazing, however, contributes greatly to its nutritive value. Spanish clover (*Lotus americanus*) and hill lotus (*Lotus humistratus*) are less important representatives of leguminous plants. They usually constitute only a small percentage of the total forage on foothill ranges. Since they normally remain green after grasses and filaree have dried, they are relished at this time and extend the period of adequate nutrition of the animals.

Various species of vetch occur in the mountains and in some foothill areas. They are commonly referred to as "pea vines" by stockmen and are relished by livestock.

The average chemical composition of large numbers of samples of representatives of these types of annual forage, that were collected during different seasons of the year from various range areas, is shown in table 5.

Perennial Grasses.—Perennial grasses, along with sedges and rushes, make up the principal forage in higher ranges and mountain meadows. Perennial bunch grasses in significant amounts are found on some coast ranges and partially depleted stands respond to judicious grazing practices. Some bunch grass also remains in northeastern California ranges and in high mountain areas. Salt grass (*Distichlis spicata*), a sod-forming perennial, occupies large areas of alkaline valley land, remains green during most of the summer and provides fair forage for cattle. Bermuda grass occupies extensive areas of low lands, and though it is a serious pest in cultivated crops, it furnishes good pasture for livestock during the summer. The chemical characteristics of all these grasses are somewhat similar though some are much more fibrous and lower in palatability than others. The mature dry forage of the coarser, tall-growing perennial bunch grasses is low in protein, high in fiber and relatively unpalatable. In general the more fine leafy material there is available the more nutritious is the cured forage. One of the outstanding advantages of the perennials is that they start growth more quickly and, being deep-rooted, remain green longer than annuals, which prolongs the period of favorable feed conditions. All practical means of encouraging valuable perennial grass species is desirable for improvement of range feed supply.

Browse.—Bluebrush (*Ceanothus integerrimus*) often locally called deer brush or sweet birch is one of the most important browse species in

foothill and mountain areas. Thick stands frequently develop after fires, and cattle make good gains on this as practically the sole forage for periods of from two to four months. Young stands of low-growing browse provide better forage than older plants which eventually get too high for grazing cattle. Bluebrush decreases in phosphorus and increases in

TABLE 5

AVERAGE PERCENTAGE COMPOSITION OF REPRESENTATIVE ANNUAL FORAGE SPECIES
SHOWING SEASONAL CHANGES*

	Crude protein	Nitrogen- free extract and fat	Crude fiber	Total minerals†	Calcium	Phos- phorus
Bur clover:						
Early green stage.....	32.9	44.7	12.8	9.7	1.1	0.45
Bloom stage.....	24.2	49.2	18.2	8.4	1.5	.40
Seed stage.....	22.8	47.5	22.2	7.4	1.2	.32
Mature, dry.....	16.7	46.4	30.7	6.1	1.5	.24
Wild oats:						
Early green stage.....	14.2	57.4	22.0	6.4	0.41	.38
Bloom stage.....	10.0	54.7	31.3	4.0	0.24	.29
Seed stage.....	7.6	55.9	33.3	3.2	0.23	.25
Dry, seeds shattered.....	5.4	58.4	32.6	3.7	0.26	.18
Dry, leached.....	3.6	59.6	34.5	2.3	0.23	.11
Soft chess:						
Bloom stage.....	13.6	53.6	28.2	4.6	0.35	.37
Seed stage.....	11.5	59.1	26.1	3.3	0.31	.33
Mature, dry.....	7.7	60.9	28.0	3.4	0.35	.26
Dry, leached.....	6.9	60.5	30.1	2.5	0.41	.14
Red-stem filaree						
Early green stage.....	29.8	45.4	11.3	13.5	2.2	.46
Bloom stage.....	17.8	51.1	18.8	12.3	2.3	.46
Seed stage.....	15.9	51.8	20.4	11.8	2.6	.38
Mature, dry.....	8.5	55.6	22.8	13.1	3.0	.18
Dry, leached.....	5.5	58.9	29.1	6.5	2.6	.14
Broad-leaf filaree:						
Early green stage.....	25.0	52.1	12.1	10.8	1.7	.39
Bloom stage.....	14.6	55.1	22.1	8.2	1.4	.35
Seed stage.....	11.2	54.0	27.0	7.9	1.4	.32
Mature, dry.....	6.4	57.2	28.3	7.9	1.7	.13
Dry, leached.....	5.9	58.6	30.0	5.9	1.9	0.08

* All figures are expressed on the basis of moisture-free samples.

† Total minerals represent silica-free ash.

calcium as it matures, and this may be involved in poor results late in the season. The stems and shoots also become tough, particularly on old plants, and the animals may have difficulty in getting a fill of leaves, compared with browsing leaves along with tender shoots early in the season. Bluebrush contains saponin, but its toxicity for cattle has not been demonstrated.

The seasonal changes in composition of bitterbrush (*Purshia tridentata*), and mountain-mahogany (*Cercocarpus montanus*) appear similar to those of bluebrush. Among other species that may contribute considerable forage in some areas are serviceberry (*Amelanchier alnifolia*), coffee-berry (*Simmondsia californica*), poison oak (*Toxicodendron diversilobum*), and leaves of various oak species. Leaves of mountain white oak (*Quercus Garryana*) of northwestern California appear to be higher in feed value than those of other species. Various mesquite species and screw beans are important browse plants in some desert areas. The seeds and pods are rich in protein and especially nutritious.

In general the protein content of browse species including desert and semidesert plants such as sages (*Artemisia* spp.), winter fat (*Eurotia lanata*), and shadscales (*Atriplex* spp.) is higher than that of dry grasses and weeds. If fairly palatable species are present in sufficient quantities they constitute a valuable supplement to dry forage, and by remaining green and succulent provide carotene, the precursor of vitamin A. Spanish moss and mistletoe also have these supplementary values. Consumption of liberal quantities of mistletoe does not cause abortion in cattle or sheep. The chemical composition of various browse species is given in table 6.

Acorns.—During some years the acorn crop is heavy, and utilization of this large potential feed resource is an important problem. Stockmen are divided in opinion regarding the effects of acorns on cattle. Some report ill effects, while others claim the acorns aid materially in carrying cattle when other feed is scarce. The variations in effects observed may depend on the kind of acorns and also the nature of other available feed.

Different varieties of acorns vary in chemical composition. Some are high in oil, while others are comparatively low. The tannin content is likewise variable. High fat content, as well as tannin and other intestinal irritants, may contribute to diarrhea. All acorns are low in protein and minerals, but they may have considerable value if the ration is otherwise complete. This is confirmed by observations that cattle do well at least on some kinds of acorns when cottonseed cake is fed or green forage is available.

Effect of Rain on Dry Forage.—Laboratory experiments^{7, 8} have shown that dried forage contains from 8 to 20 per cent of water-soluble material, most of which is leached out by rains after the forage has dried. Soluble carbohydrates make up the larger part of this loss, though the

⁷ Guilbert, H. R., and S. W. Mead. Digestibility of bur clover as affected by exposure to sunlight and rain. *Hilgardia* 6:1-12. 1931.

⁸ Guilbert, H. R., S. W. Mead, and H. C. Jackson. Effect of leaching on the nutritive value of forage plants. *Hilgardia* 6:13-26. 1931.

highest loss on a percentage basis is in the mineral, the loss of which may vary from 30 to nearly 70 per cent of the total mineral content. Nearly all the common salt is removed, and this partially accounts for the stockmen's observation of increased salt consumption after late rains have "spoiled" the feed. The percentage loss of protein in laboratory experi-

TABLE 6
AVERAGE PERCENTAGE COMPOSITION OF VARIOUS BROWSE SPECIES*

Browse and stages sampled	Crude protein	Nitrogen-free extract and fat	Crude fiber	Total minerals†	Calcium	Phosphorus
Bluebrush or sweet birch:						
Leaves and new shoots, May 9.....	29.2	50.7	13.6	7.5	1.3	0.56
Leaves and new shoots, May 26.....	20.7	56.2	15.8	7.2	1.0	.24
Leaves and new shoots, June 21.....	22.5	60.1	10.0	7.5	1.9	.21
Leaves and seeds, July 8.....	24.4	59.6	9.5	6.5	1.8	.22
Leaves and few seeds, August 22.....	16.9	65.4	10.9	6.8	2.5	.12
Leaves only, September 19.....	14.3	71.8	6.9	7.1	2.0	.11
Seedling twigs and whole plants, July 23.....	25.0	57.1	11.3	6.6	0.8	.31
Bitterbrush:						
Leaves and twigs, May 19.....	15.0	62.8	18.7	3.5	0.72	.24
Leaves, August 6.....	13.3	65.3	16.1	5.4	1.52	.18
Leaves, September 14.....	11.6	68.2	16.2	3.9	1.2	.13
Mountain-mahogany, August 7.....	16.1	55.1	22.6	6.3	1.2	.13
Chokecherry, July 23.....	21.5	63.3	9.3	5.9	1.4	.25
Oak leaves:						
Mountain white oak, August 15.....	18.7	.....	.....	.....	0.8	.26
Mountain white oak, September 20.....	16.3	.....	.....	.....	0.9	.17
Mountain white oak, October 15.....	14.3	.....	.....	.....	1.2	0.30
Mountain white oak, ‡ September.....	15.7	47.8	17.0	9.9	.....	.....
Blue oak, ‡ September.....	8.8	41.3	35.2	9.8	.....	.....
Cañon live oak, ‡ September.....	11.4	38.1	30.6	10.0	.....	.....
Black oak, ‡ September.....	8.6	50.1	20.3	9.9	.....	.....
Poison oak leaves, ‡ September.....	7.2	50.3	26.6	9.2	.....	.....
Serviceberry, large-leaved§.....	14.3	60.1	23.6	1.9	.....	.....
Serviceberry, small-leaved§.....	16.1	61.7	14.4	7.7	.....	.....

* All figures are expressed on the basis of moisture-free samples.

† Total minerals represent silica-free ash.

‡ The tannin analyses of these samples varied from 5.3 to 14.6 per cent and are not included with the nitrogen-free extract and fat. The total of the protein, nitrogen-free extract and fat, fiber, and ash does not therefore equal 100 per cent. Data from: Mackie, W. W. The value of oak leaves for forage. California Agr. Exp. Sta. Bul. 150:1-21. 1903. (Out of print.)

§ Data from: Dayton, W. A. Important western browse plants. U. S. Dept. Agr. Misc. Pub. 101:1-213. 1931.

ments varied from 7 to 18 per cent of the total. The percentage of protein in the leached residue remains about the same or may even be higher because of larger losses of other constituents. The crude fiber content of the residue after leaching is higher. Digestion experiments show a decrease in digestibility of all nutrients except fiber after the soluble

ingredients are leached out by rain. An example of how apparently small changes in digestibility may affect nutrients available for gain is shown in digestion experiments with bur clover before and after being leached by 0.7 inch of rain. In 20 pounds of bur clover there were 12.5 pounds of digestible nutrients before leaching and 10.7 pounds after leaching. Since about 8 pounds of these nutrients are needed for maintenance of a 1,000-pound steer, it will be seen that with the unleached clover, 4.5 pounds would be available for gain, whereas with the leached, only 2.7 pounds would be available for gain. Although the leaching caused a de-

TABLE 7
DIGESTION TRIALS WITH RANGE FORAGE

Types of forage	Digestible nutrients in 100 pounds	
	Crude protein	Total
	pounds	pounds
Dry mixed annual grasses, soft chess predominating, cut for hay when practically mature*.....	none	51.1
Mixed red-stemmed and broad-leaf filaree bleached and leached by rain (gathered from range)†.....	none	41.2
Bur clover, harvested at seed stage and cured as hay‡.....	13.1	62.5
Bur clover, harvested as above, bleached and leached by 0.7 inch of rain‡	11.4	53.8

* California Agr. Exp. Sta. Report 1926-27:48-49. 1928. (Out of print.)

† Digestion trial conducted by A. Folger. Reported in: Hart, G. H., H. R. Guilbert, and H. Goss. Seasonal changes in the chemical composition of range forage and their relation to nutrition of animals. California Agr. Exp. Sta. Bul. 543:1-62. 1932. (Out of print.)

‡ Guilbert, H. R., and S. W. Mead. The digestibility of bur clover as affected by exposure to sunlight and rain. Hilgardia 6(1):1-12. 1931.

crease of about 15 per cent in digestibility, the nutrients available for gain would be decreased about 40 per cent. This occurs under practical conditions, since animals are limited in the amount of total feed that they can consume. The effect is apt to be greater than indicated, since removal of soluble nutrients, responsible for the taste of feed, decreases palatability. If range feed remains wet for a considerable time, further damage is caused by molds and other decomposing agencies. Moreover, there may be considerable loss of leaves by shattering and beating into the soil by heavy rain.

Digestion Experiments with Range Forage.—Table 7 gives the results of digestion experiments with range forage. The palatability of the dried grass and filaree was so low that the sheep used in the digestion trials consumed only a little more than a pound daily, and under these conditions there appeared to be no digestible protein. Whether this would obtain under conditions of selective grazing on the range is a question, but the results do emphasize the significance of the protein deficiency of such

feeds compared with the relative abundance of this nutrient in bur clover. The table shows that even the dry, leached filaree has considerable energy value for maintenance if its protein deficiency is overcome by the use of supplements.

CHARACTERISTICS OF HARVESTED ROUGHAGES, GRAINS, AND BY-PRODUCTS

Legume Hays.—Legume roughages such as alfalfa and various clovers are higher in protein (table 8) than other forage crops; the protein is of excellent quality, the calcium content is high, and when well cured they contain liberal amounts of vitamin A and other accessory nutrients. For these reasons they are especially valuable to feed in combination with cereal grains and other carbohydrate feeds.

Tests at the Kansas Agricultural Experiment Station showed that gains of cattle were greatest on hay cut at the bud stage, next at one-tenth bloom, and least when mature. Hay from the early stages is somewhat laxative. From the standpoints both of feed value and yield of digestible nutrients, early to one-half bloom stages are preferable for cattle. Careful curing saves leaves, the most nutritious part of the plant, and results in higher protein content and conservation of minerals and other important nutrients. Carotene is rapidly lost during curing and sun exposure so that about 75 per cent is lost even under most favorable conditions for sun-curing. Nearly all carotene disappears in slow-cured and in bleached hays. Proper haymaking increases not only feed value, but also yields per acre, and palatability, and it reduces waste in feeding.

Nonlegume Hays.—California is a leading state in production of cereal hay, and large quantities are used in beef-cattle feeding. Grain hays are low in protein and calcium, compared with the legumes. As it is ordinarily cured, most of the vitamin-A value is bleached out, but when there is a significant amount of green color the amount of carotene present will suffice to prevent deficiency. California feeding tests and practical experience have demonstrated that results comparable to those with alfalfa are obtained in fattening cattle when the protein and other deficiencies are properly supplemented. Mixed hays such as wild oats and bur clover, and oats and vetch, are intermediate in characteristics. The feeding of both legume and nonlegume roughage is frequently preferable to either alone. Meadow hay is variable according to the soil, moisture condition, and type of grasses and grasslike plants of which it is composed. Unless there is clover in the mixture, meadow hays have much the same characteristics as the grain hays.

The Washington Agricultural Experiment Station has shown by

chemical analyses and by digestion trials that the medium dough stage of maturity is most desirable for wheat, beardless barley, and oat hays. The increased digestibility found for later stages was more than offset by shattering and leaf loss, under practical conditions. Curing to conserve green color is important not only from the standpoint of palatability but also in retaining carotene.

Straw.—As plants mature, nutrients formed in the green parts are largely transported to the ripening seeds and the straw that is left is low in protein, minerals, starch, fat, and vitamins, and is high in fiber. The digestibility and productive value is much lower than in hays from the same plants cut at earlier stages of maturity. Chaff and leaf material have a higher value than the coarser stems. When economically handled and adequately supplemented, the straws can be marketed to advantage through cattle. Recommendations for their utilization are given in the third and fourth parts of this circular.

Silage.—When corn and sorghum crops are ensiled, rather than fed as dry roughage, such feeds are better conserved. Silage adds succulence and palatability to rations. Corn and sorghum silage require protein supplements. The total feed value as indicated in table 8 and confirmed by feeding tests is approximately one half that of average-quality hay. The tonnage secured and cost of production in comparison with hay are important considerations. Cheap trench silos reduce overhead cost. A small acreage of silage crops may frequently be a way of increasing feed supply for wintering young cattle, and when fed with legume hay produces good gains without additional concentrate supplements. Silage is a valuable feed in fattening rations and for all classes of cattle. Sorghum should be cut for silage when the grain is mature, otherwise the silage may be too acid. Silage from legumes and grasses may be satisfactorily made by adding 60 to 75 pounds of molasses to each ton of green forage as it goes into the silo.

Roots and Tubers.—The relative values of some roots and tubers are shown in table 8. When they can be grown economically or culls are available at low cost, they can be effectively utilized in cattle rations. Roots and tubers are high in moisture, low in fiber, and the dry matter is highly digestible. Roots may be used in the same manner as silage. Sugar beets and potatoes properly fed have a value only slightly lower than corn silage. Sugar beets, mangels, and potatoes should be chopped or sliced for feeding. Stock should be gradually accustomed to such feeds, particularly potatoes; too large amounts may cause scours. Because of solanine, a toxic substance present in small amounts, badly sunburned or sprouted potatoes should be fed in limited amounts as a matter of safety, although

liberal quantities have been fed to cattle without apparent injury. Care should be taken to supply adequate amounts of protein feeds when roots and tubers are used in the ration. An efficient way to store and to utilize root crops is to chop them into a silo along with corn or other silage or with dry roughage sufficient to take up excess moisture. Preliminary tests indicate that the addition of 4 per cent molasses to potatoes produces sufficient fermentation to result in good silage with a pleasing odor. It is estimated that about 10 per cent dry roughage should be added to take up excess moisture. Potatoes have been artificially dehydrated, but the cost of this processing may be prohibitive. Limited experience in Kern County suggests the practicability of sun-drying cull potatoes when they are harvested under hot, dry-weather conditions. Sun-dried whole potatoes become very hard and should be ground before feeding, unless they are intended for feeding on the range without troughs, when they may be fed without grinding if sliced before they are dried. If fed in moderate amounts in mixed rations the dry matter of potatoes should have a value approximating that of grains.

Grains.—The common grains, although differing slightly in feeding value as shown in table 9, are similar in their general characteristics and are replaceable one for the other in cattle rations. All grains are relatively low in protein and should be fed either with legume roughage, young green forage, or with a protein-rich supplement. Grains are moderately rich in phosphorus but low in calcium. All except yellow corn are deficient in vitamin A.

Barley is the basic carbohydrate concentrate feed in California. The average value for digestible protein and total digestible nutrients is shown in table 9. The normal range of variation in chemical analyses of rolled and ground barley is from 7 to 13 per cent total protein and from 4 to 8 per cent crude fiber. Immature barley that is not "well-filled" may run higher in protein, but because of high fiber is lower in feeding value. The poorer grades of barley may be utilized, but they are inferior to plump, heavy grain, particularly in fattening rations. Barley is fairly palatable to cattle but produces best results when fed in combination with other concentrate feeds.

Grain sorghums, such as milo, feterita, and kafir, are lower in fiber than barley and are slightly higher in feeding value. They may be used as the only grain in fattening rations but combine well with other grains, especially barley. Ground grain-sorghum heads have somewhat lower feeding value than the ground threshed grain. If, however, allowance is made for the included roughage by feeding increased amounts, results are comparable to those with threshed grain. This method of handling

eliminates threshing and is economical. The relatively high moisture content that may be found in threshed grain sorghums often presents difficulties with molding during storage.

Wheat has a slightly higher feeding value than dent corn but gives best results when it replaces not more than half of the concentrate ration.

Oats are too bulky for a satisfactory fattening feed but are excellent for growing cattle and as part of the mixture in starting cattle on feed.

Dent corn ranks between grain sorghums and wheat in total feed value. This, together with high palatability, makes corn a most desirable fattening feed. It is not extensively grown in California and is not ordinarily available at favorable prices.

Mill Feeds.—Mill feeds are most extensively used in California for dairy cattle and swine. When prices justify, they may be satisfactorily fed to beef cattle. It is seldom advisable to use the mill feeds to replace more than 25–30 per cent of the concentrate ration for beef cattle. All of these feeds are palatable. Mill-run, wheat middlings, and rice polish are higher in proteins than grains and comparable to them in total digestible nutrients. Rice bran and wheat bran contain more fiber than grains and are somewhat bulky. Wheat bran is valuable in rations for growing cattle and in fitting animals for show or sale.

Beet By-Products.—Fresh pulp from the sugar factories contains 90 to 95 per cent water. When passed through a press the moisture content is reduced to 85–90 per cent and the product is called pressed pulp. Siloed pulp is wet pulp that has undergone fermentation similar to silage and eventually forms a more or less cheesy mass. The moisture content usually varies from 87 to 90 per cent in well-cured siloed pulp.

It should be recognized that a small reduction in percentage of moisture greatly enhances dry matter content of wet-pulp products; for example, if by pressing the pulp moisture content is reduced from 95 to 90 per cent, the dry matter is doubled. Since moisture content of wet pulp is high and variable, price adjustment should be made by the sugar factories on the basis of dry-matter content and feeders should compare the cost of digestible dry matter with other common feeds.

Dried molasses beet pulp is produced by spraying or mixing molasses with wet pulp and dehydrating the two together. The dried product commonly contains 8 to 10 per cent of moisture. The amount of molasses in the dried product is variable, but probably averages about 30 per cent of the total dry matter.

All beet-pulp products are low in protein and deficient in phosphorus.

Beet pulp is bulky in nature and has physical characteristics resembling roughage. The fiber is highly digestible, however, so that the feed

value of the dry matter is comparable to that of barley. Beet pulp is an excellent feed to combine with barley. Such a mixture may be fed more heavily without danger of digestive disturbances.

Beet tops consist of the beet leaves and the crown of the beet. In California, beet tops are utilized mainly by pasturing in the field. Under these conditions variation due to moisture and amount of adhering dirt is very great. An average figure for digestible composition is given in table 8. The dry-matter yield of tops is roughly 10 to 15 per cent of the weight of the beets produced. Tops usually consist of about 40 per cent crown and 60 per cent leaf. The proportion is variable, however, and crowns may be as low as 25 per cent of the total dry substance, in the case of small beets.

Analyses of beet tops show variations of 8 to 23 per cent protein, 9 to 16 per cent fiber, and 33 to 66 per cent nitrogen-free extract. Total ash including dirt varies from 14 to 35 per cent. At the California station the average percentage composition of five samples of tops and of two samples each of leaves and of crowns was determined to be as follows:

	Crude protein	Nitrogen-free extract and fat	Crude fiber	Ash
Tops	9.0	59.0	13.0	19.0
Leaves	13.5	45.8	19.2	21.5
Crowns	8.1	80.2	6.9	4.8

Fresh sugar-beet leaves are reported to contain 3 to 6 per cent oxalic acid. The amount decreases with wilting and drying. For this reason it is desirable to delay turning cattle on tops until about a week after harvest. Kellner, a German worker, recommended feeding $\frac{1}{4}$ pound of calcium carbonate for each 250 pounds of beet tops to render the oxalic acid harmless. The Colorado Agricultural Experiment Station reports that the scouring effect of beet tops in a fattening ration was readily controlled by feeding $\frac{1}{10}$ pound of lime (calcium carbonate) daily. Excess oxalic acid causes intestinal irritation, lowering of blood calcium, muscular weakness, and tends to produce urinary calculi. Apparently considerable oxalic acid is decomposed in the paunch of cattle. The exact effect on cattle of oxalic acid in beet tops is not clear. The large amounts of adhering dirt and the minerals in the tops probably contribute to scouring. If practical means of inducing animals to take calcium carbonate under field conditions can be found, it may be beneficial in counteracting these effects.

Although cattle may fatten more readily when eating largely crowns, conservation and utilization of leaf material are important in realizing the most from this feed resource. The high carbohydrate and low fiber

content of the crowns make them a better fattening feed than the leaves. The leaves, however, furnish protein to balance the deficiency of the crowns. Utilization of beet tops is discussed in the last part of this circular.

Dried Fruits and Fruit By-Products.—Fruits and their by-products are sometimes available for fattening cattle at favorable prices. They are all low in protein and high in carbohydrates. Prunes, raisins, figs, dried peaches, and dried pears are palatable to cattle and have been fed to mature animals in quantities up to 4 to 6 pounds daily with satisfactory results. Reference to table 9 will show their value relative to barley. These fruits tend to be laxative when fed in excess. A good rule is to limit such feed to about 30 per cent of the concentrate rations. Dried apple pulp is similar in composition to beet pulp and may be used in much the same manner. Dried orange pulp and other citrus pulps compare favorably with barley in total feed value. Dried pineapple pulp and raisin pulp are lower in feed value because of higher fiber content.

Molasses.—Most of the molasses used in California is cane or blackstrap. Beet molasses, including Steffens discard, has been reported to be fairly similar to cane molasses in feeding value although it is apparently not so palatable and is more laxative. Ordinary feed analyses show Steffens-discard beet molasses to have 6 to 9 per cent protein. Much of this is not true protein, however, and its value for nutrition of cattle is questionable. The dry matter of cane molasses is low in protein; it consists largely of sugars, and about 9 to 12 per cent of mineral matter. The moisture content usually varies from 18 to 20 per cent. It is very palatable but is laxative when fed in excess. In California it is commonly a cheap source of carbohydrates and for this reason may be used to the extent of 20 to 25 per cent of concentrate rations or up to 10 to 15 per cent of the total ration when grains and ground roughages are fed mixed. Fifteen to 20 per cent is about the right amount to mix with ground roughage to keep down dust and still not cake badly in storage. Molasses is also valuable in mixed ground rations to reduce dust, and by the added palatability, makes more effective use of low-grade feeds. Numerous experiments have demonstrated that molasses does not have a value in excess of that indicated by its digestible nutrients when added to an already excellent ration consisting of a variety of palatable feeds. When other palatable feeds are included in the ration, molasses may be self-fed. It may also be fed by pouring or spraying over grain or roughage in troughs or by pouring in troughs and placing grains or other feeds on top of the molasses. Molasses at ordinary temperature weighs about 11.8 pounds per gallon. When mixed with feeds it is thinned either by heating or by

diluting with water. For detailed information on methods of feeding and handling, consult the Agricultural Extension Service.

Brewery and Distillery By-Products.—Wet brewers' grains, unless pressed to remove part of the moisture, contain about 25 per cent dry matter. The fermentation process removes most of the starch, leaving a residue higher in fiber, protein, and fat, but lower in total feed value than the original grains. When fed fresh, wet brewers' grains are palatable and wholesome. Because of high moisture, souring and molding occur unless they are fed within a short time after production. The digestible nutrient values for the dried grains are shown in table 9.

Distillery slop contains about 94 per cent water. It can be fed to cattle by pumping into troughs. Molasses and grains can be added to replace carbohydrates removed by fermentation. The recovery of dry matter in the slop is about 35 per cent of that in original grains. The liquid which may be strained off contains about 2 per cent dissolved solids. The dry matter is high in protein and fat, but distillers' corn grain is lower in fiber than brewers' grains. Because of high fat content, the total digestible nutrient value is higher than the original grain as shown in table 9. Distillers' rye grain is low in feeding value, and relatively unpalatable.

Protein-Rich Concentrates.—In California cottonseed meal or cake is the most commonly used protein-rich cattle feed. At times, however, soybean meal, linseed meal, fish meal, and other similar feeds are available in quantity and compete as economical sources of protein. These feeds, therefore, should always be considered when purchasing protein supplements.

Cottonseed meal or cake varies in composition according to the manufacturing process. Whole-pressed cake contains the residue after crushing and pressing the oil from the whole seed including the hull, and therefore is higher in fiber and lower in protein than cottonseed products obtained from hulled seeds. Whole- or cold-pressed cake is soft and bulky and is, for these reasons, sometimes preferred for starting cattle on feed or when the price is favorable for using large quantities as a fattening feed rather than as a protein supplement. Only limited quantities are available. Cottonseed meal or cake other than the cold- or whole-pressed cake is available mostly in two grades, namely, of 41 per cent protein and 43 per cent protein; it is sold in various forms such as nut-sized, sheep-sized, or pea-sized cake and as meal. Cottonseed by-products contain small amounts of a toxic substance called gossypol. This substance does not, however, appear to have a toxic effect on cattle, except possibly on very young calves. The so-called poisonous effect experienced with cattle is now known to be vitamin-A deficiency which occurs after varying pe-

riods of time when no green forage or hay is included in the ration. Dairy cows at the Oklahoma Agricultural Experiment Station have been fed an average of over 10 pounds daily of cottonseed meal through three successive gestation and lactation periods without ill effect when sufficient carotene, the precursor of vitamin A, was present in the hay. Whole cottonseed, because of its oil content, is higher in digestible nutrients but lower in protein than the meals or cakes. It is a satisfactory feed and may be used when the price makes it economical.

Linseed meal, although somewhat lower in digestible protein than 43 per cent cottonseed meal, in numerous experiments with fattening cattle, has given results equal or superior to cottonseed meal. Linseed meal is slightly laxative, appears to have a tonic effect, and is particularly credited with the production of "bloom" and fine condition of hair.

Fish meal of high quality and low in free fatty acids is an excellent protein feed having about 40 per cent more digestible protein than cottonseed meal. Cattle take it readily in mixed rations and range calves have been taught to eat it alone in a few days at weaning time.

Meat meal or tankage has also been successfully used as a protein supplement in fattening rations, and the value was about proportionate to the digestible protein content.

Sesame meal is palatable, gives excellent results as a cattle feed, and has about the same value as 43 per cent cottonseed meal. Soybean meal is slightly higher both in digestible protein and in total digestible nutrients than 43 per cent cottonseed meal. Feeding tests with cattle show practically equal values for the two feeds.

Peanut meal is very similar in value to soybean and cottonseed meal.

Coconut meal contains only about one half the protein content of 43 per cent cottonseed cake but is slightly higher in total digestible nutrients. It is fairly palatable to cattle when fed with other concentrate feeds.

Perilla meal, hempseed meal, and babassu meal are relatively new feeds and appear on the market in limited and variable quantities.⁹

Mixtures of protein concentrates have in general been equal to linseed meal and superior to some of the individual protein feeds fed alone.

PREPARATION OF FEEDS

All small grains such as barley, wheat, grain sorghums, and oats should be ground or rolled for cattle feeding. Some feeders prefer rolled to ground barley because it may be more uniform and less wasteful to feed

⁹ Details of digestion experiments on these feeds are given in: Folger, A. H. The digestibility of perilla meal, hempseed meal, and babassu meal, as determined for ruminants. California Agr. Exp. Sta. Bul. 604:1-8. 1937.

in windy weather. In the absence of wind loss, a careful feeder will obtain the same results from feeding either ground or rolled grain. Medium to coarse grinding is preferable to fine grinding for cattle feeding, and the cost of grinding is much less. Dent corn need not be ground for cattle if hogs are run with them to recover the waste; otherwise corn should also be ground.

Chopping or grinding of hay or other roughage decreases necessary storage space, saves waste in feeding, and in some cases may save labor in feeding, but it does not increase the digestibility of the feed. The saving of labor of chewing by the animals does not materially affect the net value of the feed. Fine grinding of roughage may actually decrease digestibility, probably because such forage does not remain for a normal time in the rumen, where it is subjected to bacterial digestion. Feeding of chopped or ground hay mixed with concentrates does not improve the feed value of the feeds used nor make the ration better balanced than the same feeds fed separately, although there may be advantages in convenience and safety in feeding. In general the poorer the quality of the roughage, the greater is the saving of wasted feed by chopping. On the other hand, the lower the price of the roughage the greater the saving must be to pay chopping costs. When properly fed in suitable racks there is little waste in feeding high-quality hay. If more attention is given to harvesting and curing of roughage there will be less necessity for mechanical preparation. Frequently there is too much overhead cost in equipment and machinery for feed lots. A saving of about 20 per cent would be necessary to cover cost of chopping hay when it is valued at \$10 per ton. In general, tests conducted at various experiment stations have shown that chopping and grinding of roughage was not economical. Chopped hay requires only one third to one half as much storage space as long hay. Information on types of mills, power requirements in relation to fineness of grinding, and grinding costs can be obtained from the Agricultural Extension Service.

DETERMINATION OF THE MOST ECONOMICAL FEEDS

Ordinary feed analyses give the crude protein, nitrogen-free extract, fat, fiber, and ash content of feeds, but do not show the amounts of these constituents that are digestible, and, therefore, available to the animal. The value of individual feeds depends not only on the amount of digestible nutrients they contain, but also upon their palatability, physical effect, and whether or not they are combined with other feeds to furnish the quantity and quality of protein, essential minerals, and vitamins necessary to form a *complete* ration. If this information concerning in-

dividual feeds, together with rules and suggestions for using them in complete rations, is considered, then their relative values may be expressed with reasonable accuracy upon the basis of their *digestible protein* and total *digestible nutrients*. It should be recognized, however, that feeds may vary from the average analyses.

Columns 1 and 2 of tables 8 and 9 give the digestible protein and total digestible nutrients in common California feeds. These figures for digestible nutrients are the bases for the three methods presented in the tables for determining most economical feeds at varying prices per ton.

How to Use Method 1.—Use this method when you desire to *compare different feeds directly with barley and when the price of common high- and low-protein feeds is about the same*. Under this method, the total digestible nutrient value of all feeds is expressed in percentage of that in barley; further, it enables one to compute directly the relative value of feeds in dollars per ton.

To find the value of any feed compared with barley, multiply the current barley price by the factor listed opposite that feed in column 3.

Example: If barley is quoted at \$25 per ton, what is rice bran worth? Barley price, \$25 per ton \times 0.86 (the total digestible nutrient factor for rice bran) = \$21.50, the relative value compared with barley.

A series of feeds may be computed in this manner and a comparison of their relative values with actual market prices will show the feeds that will furnish digestible nutrients at the lowest cost.

How to Use Method 2.—Use this method when you desire to *find the cost of 100 pounds of digestible nutrients in any feed and when the price of common high- and low-protein feeds is about the same*. To find the cost of 100 pounds of digestible nutrients in any feed, find the figure opposite the name of the feed and in the column corresponding to the price per ton at which the feed is quoted (columns 4–11).

Example: with barley at \$25 per ton (column 6), the cost of digestible nutrients = \$1.58 per hundredweight; with oats at \$25 per ton (column 6), the cost of digestible nutrients = \$1.73 per hundredweight; and with cane molasses at \$20 per ton (column 5), the cost of digestible nutrients = \$1.64 per hundredweight.

Thus barley at \$25 per ton is a cheaper source of digestible nutrients than oats at \$25 or molasses at \$20. Since the cost of digestible nutrients increases directly with the feed price, costs at prices lying between the values given in the table can be calculated.

How to Use Method 3.—Use method 3 *when the price of protein-rich feeds is higher than that of carbohydrate feeds*. Under these conditions, if either method 1 or 2 is used, intermediate feeds in protein content are

underrated, and low-protein feeds are overrated. Method 3 takes into account both the protein and nonprotein digestible nutrient value of feeds. Barley is taken as a standard carbohydrate feed and cottonseed meal of 43 per cent protein as a standard high-protein feed. Barley and cottonseed-meal factors are given for each feed listed in the table.

In using this method, calculations are in three steps as follows: (a) Multiply the barley price by the barley constant (column 12) for the feed in question. (b) Multiply the cottonseed-meal price by the cottonseed-meal constant (column 13) for this feed. (c) Add the results together if both factors are positive, or subtract if one of the factors is preceded by a minus sign. The result will be the value in dollars per ton of the feed compared with that of barley and cottonseed meal.

Example: What is the value each of coconut meal, of molasses, and of alfalfa hay when barley is quoted at \$25 per ton and cottonseed meal at \$35 per ton?

Barley price times the barley constant for coconut meal ($\$25 \times 0.65$)	= \$16.25
Cottonseed-meal price times the cottonseed-meal constant for coconut meal ($\$35 \times 0.40$)	..... = 14.00
Value per ton of coconut meal	\$30.25
Barley price times the barley constant for molasses ($\$25 \times 0.95$)	= \$23.75
Cottonseed-meal price times the cottonseed-meal constant for molasses ($\$35 \times -0.18$)	..... = - 6.30
Value per ton of molasses	\$17.45
Barley price times the barley constant for alfalfa ($\$25 \times 0.29$)	.... = \$7.25
Cottonseed meal price times the cottonseed-meal constant for alfalfa ($\$35 \times 0.25$)	..... = 8.75
Value per ton of alfalfa hay	\$16.00

Based on the above calculations, if alfalfa could be bought for \$12 per ton, molasses for \$14, and coconut meal for \$32, the first two would be relatively cheap feeds and the latter relatively high.

Use of the table as directed is important in compounding economical rations, because feeds that cost the least per ton do not necessarily furnish essential nutrients at the cheapest rate. By affording a direct comparison of the relative values of roughages and concentrates, the economy of full feeding or of limited feeding of concentrates is indicated.

TABLE 8
DIGESTIBLE NUTRIENTS IN ROUGHAGES, SILAGE, AND ROOTS, AND THEIR COMPARATIVE FEED VALUES AS DETERMINED BY
THREE DIFFERENT METHODS*

Feeds	Pounds digestible protein in 100 pounds	Pounds total digestible nutrients in 100 pounds	Total digestible nutrients as percentage of barley value (use with method 1)	Cost (in dollars) of 100 pounds of digestible nutrients at varying prices per ton of feed (use with method 2)								Constants† (use with method 3)	
				\$2	\$4	\$6	\$8	\$10	\$15	\$20	\$25	For barley	For cottonseed meal of 43 per cent protein
	1	2	3	4	5	6	7	8	9	10	11	12	13
Roughages, dry:													
Alfalfa hay, average.....	11	42	53	0.24	0.48	0.71	0.96	1.19	1.79	2.38	2.98	0.29	0.25
Alfalfa hay, very leafy (less than 25 per cent fiber)....	13	45	57	0.22	0.44	0.67	0.89	1.11	1.67	2.22	2.78	.27	0.31
Alfalfa hay, fair (more than 30 per cent fiber).....	10	40	51	0.25	0.50	0.75	1.00	1.25	1.88	2.50	3.13	.30	0.22
Barley hay, medium dough stages.....	4	39	49	0.26	0.51	0.77	1.02	1.28	1.92	2.56	3.20	.49	0.01
Barley straw.....	1	23	29	0.43	0.87	1.30	1.74	2.17	3.26	4.35	5.43	.34	-0.05
Bean straw, field.....	3	21	27	0.48	0.95	1.43	1.90	2.38	3.57	4.76	5.95	.24	0.03
Bean straw, lima.....	6	36	46	0.28	0.56	0.84	1.12	1.39	2.08	2.78	3.47	.37	0.09
Beet tops.....	6	50	63	0.20	0.40	0.60	0.80	1.00	1.50	2.00	2.50	.60	-0.04
Cottonseed hulls.....	1	30	38	0.33	0.66	1.00	1.33	1.67	2.50	3.33	4.16	.45	-0.07
Oat hay§.....	6	36	46	0.28	0.56	0.84	1.12	1.39	2.08	2.78	3.47	.37	0.09
Oat straw.....	1	23	29	0.43	0.87	1.30	1.74	2.17	3.26	4.35	5.43	.34	-0.05
Sudan grass hay.....	4	35	44	0.29	0.57	0.86	1.14	1.43	2.14	2.86	3.57	.43	0.02
Vetch and oat hay.....	7	42	53	0.24	0.48	0.71	0.95	1.19	1.79	2.38	2.98	.44	0.10
Wild oat hay.....	4	34	43	0.29	0.58	0.87	1.16	1.47	2.21	2.94	3.68	.41	0.02
Wheat straw.....	1	18	23	0.56	1.11	1.67	2.22	2.78	4.17	5.56	6.94	.27	-0.03
Silage:													
Indian corn.....	1	19	24	0.53	1.05	1.58	2.10	2.63	.....	.....	.....	.27	-0.03
Sweet sorghum.....	1	14	18	0.71	1.43	2.14	2.86	3.57	.....	.....	.....	.19	-0.01
Roots:													
Carrots.....	1	9	11	1.11	2.22	3.33	4.44	5.55	.....	.....	.....	.11	0.00
Mangels.....	1	7	9	1.42	2.86	4.28	5.71	7.14	.....	.....	.....	.08	0.01
Potatoes.....	1	17	23	0.99	1.17	1.76	2.35	2.90	.....	.....	.....	.25	-0.03
Sugar beets§.....	1	18	23	0.96	1.11	1.17	2.22	2.78	.....	.....	.....	0.26	-0.03

* Unless otherwise indicated, these values are adapted from: Morrison, F. B. Feeds and feeding, 20th edition. Morrison Publishing Co., Ithaca, N. Y. 1936.

† The figures under the heading "total digestible nutrients" are relative values based on Morrison's revised estimates of net energy values. The actual digestible nutrients in these roughages are higher than shown in this table. Since it has been found that 1 pound of digestible nutrients from concentrates has a higher productive value than a like amount from roughage, the relative values given more nearly express the actual worth of these feeds compared with concentrates.

‡ Petersen, W. E. A formula for evaluating feeds on the basis of digestible nutrients. Jour. Dairy Science 45:293-297, 1932.

§ Calculated from data of: Sotola, J. The chemical composition and nutritive value of certain cereal hay as affected by plant maturity. Jour. Agr. Research 54:399-415, 1937.

¶ Calculated from analysis by California Agricultural Experiment Station.

TABLE 9
DIGESTIBLE NUTRIENTS IN CONCENTRATES AND THEIR COMPARATIVE FEED VALUES AS DETERMINED BY THREE DIFFERENT METHODS*

Feeds	Pounds digestible protein in 100 pounds	Pounds total digestible nutrients in 100 pounds	Total digestible nutrients as percentage of barley value (use with method 1)	Cost (in dollars) of 100 pounds of digestible nutrients at varying prices per ton of feed (use with method 2)							Constants† (use with method 3)		
											For barley	For cottonseed meal of 43 per cent protein	
				1	2	3	4	5	6	7	8	9	10	11	12	13
Apple pulp, dried.....	2	72	91	1.04	1.38	1.73	2.07	2.42	2.76	3.11	3.46	1.10	-0.20
Babassu meal.....	21	80	101	0.95	1.26	1.58	1.89	2.21	2.52	2.84	3.16	0.56	0.48
Barley, California feed†.....	8	79	100	0.95	1.26	1.58	1.89	2.21	2.52	2.84	3.16	1.00	0.00
Beans, re-cleaned.....	14	64	81	1.17	1.56	1.95	2.34	2.73	3.13	3.52	3.91	0.55	0.28
Beet pulp, molasses (dried)†.....	5	74	94	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	1.02	-0.08
Brewers' grains (dried).....	16	62	78	1.22	1.62	2.03	2.43	2.84	3.24	3.65	4.06	0.44	0.36
Coconut meal.....	19	81	103	0.93	1.24	1.55	1.86	2.17	2.48	2.79	3.10	0.65	0.40
Corn, dent no. 2.....	7	81	103	0.93	1.24	1.55	1.86	2.17	2.48	2.79	3.10	1.07	-0.03
Cottonseed (whole).....	17	91	115	0.83	1.10	1.38	1.65	1.93	2.20	2.48	2.76	0.88	0.29
Cottonseed cake, cold pressed (25 per cent protein).....	22	71	90	1.05	1.40	1.75	2.10	2.45	2.80	3.15	3.50	0.38	0.55
Cottonseed meal (41 per cent protein).....	34	74	94	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	0.01	0.97
Cottonseed meal (43 per cent protein).....	35	76	96	0.99	1.32	1.65	1.98	2.31	2.64	2.97	3.30	0.00	1.00
Distillers' corn grains (dried).....	22	85	108	0.89	1.18	1.48	1.77	2.07	2.36	2.66	2.96	0.61	0.49
Figs, dried.....	4	69	87	1.08	1.44	1.80	2.16	2.52	2.88	3.25	3.60	0.98	-0.10
Fish meal (65 per cent protein).....	60	77	97	0.98	1.30	1.63	1.95	2.28	2.60	2.93	3.26	-0.85	1.90
Hempseed meal.....	26	45	57	1.66	2.22	2.77	3.33	3.89	4.44	5.00	5.54	-0.18	0.78
Hominy feed.....	8	85	108	0.89	1.18	1.48	1.77	2.07	2.36	2.66	2.96	1.09	-0.01
Linseed meal.....	31	78	99	0.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20	0.18	0.85
Manihot meal.....	1	73	92	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	1.14	-0.22
Mill run.....	14	74	94	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	0.71	0.24

TABLE 9 (Continued)

Milo grain.....	9	80	101	0.95	1.26	1.58	1.89	2.21	2.52	2.84	3.16	0.98	0.04
Milo heads, ground.....	8	77	97	0.98	1.30	1.63	1.95	2.28	2.60	2.93	3.26	0.96	0.02
Molasses, beet, Steffen's process (20 per cent moisture).....	5	60	76	1.25	1.67	2.09	2.51	2.93	3.35	3.77	4.19	0.80	-0.03
Molasses, cane (20 per cent moisture).....	1	61	77	1.23	1.64	2.05	2.46	2.87	3.28	3.69	4.10	0.95	-0.18
Oats.....	7	72	91	1.04	1.38	1.73	2.07	2.42	2.76	3.11	3.46	0.91	0.00
Orange pulp.....	6	78	99	0.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20	1.05	-0.06
Peanut meal.....	38	82	104	0.93	1.24	1.55	1.86	2.17	2.48	2.79	3.10	0.00	1.09
Pineapple pulp.....	1	65	82	1.14	1.52	1.90	2.28	2.66	3.04	3.42	3.80	1.01	-0.19
Perilla meal.....	35	62	78	1.22	1.62	2.03	2.43	2.84	3.24	3.65	4.06	-0.22	1.05
Prunes, dried.....	1	66	83	1.14	1.52	1.89	2.27	2.65	3.03	3.41	3.79	1.01	-0.19
Raisins.....	3	69	87	1.08	1.44	1.80	2.16	2.52	2.88	3.24	3.60	1.01	-0.14
Rice bran.....	9	68	86	1.11	1.48	1.85	2.22	2.59	2.96	3.33	3.70	0.79	0.08
Rice polish.....	9	86	109	0.87	1.16	1.45	1.74	2.03	2.32	2.61	2.90	1.07	0.02
Rice, rough.....	6	69	87	1.08	1.44	1.80	2.16	2.52	2.88	3.24	3.60	0.91	-0.03
Sesame meal.....	36	77	97	0.98	1.30	1.63	1.95	2.28	2.60	2.93	3.26	-0.01	1.03
Sorghum grain, sweet.....	6	74	94	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	0.99	-0.05
Soybean meal.....	38	82	104	0.93	1.24	1.55	1.86	2.17	2.48	2.79	3.10	0.00	1.09
Tankage.....	56	78	99	0.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20	-0.69	1.75
Wheat.....	9	84	106	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	1.04	0.03
Wheat bran.....	13	70	89	1.07	1.42	1.78	2.13	2.49	2.84	3.20	3.56	0.68	0.22
Wheat middlings, standard.....	14	78	99	0.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20	0.77	0.23

* Unless otherwise indicated, these values are adapted from: Morrison, F. B. Feeds and feeding. 20th edition. Morrison Publishing Co., Ithaca, N. Y. 1936.

† Petersen, W. E. A formula for evaluating feeds on the basis of digestible nutrients. Jour. Dairy Science 15:293-297. 1932.

‡ Calculated from analysis by California Agricultural Experiment Station.

PRODUCTION OF FEEDER CATTLE

Analyses of cost studies as summarized in the first part of this circular show that four fundamental rules should be followed if feeds are to be marketed most efficiently through the production of feeder cattle.

1. Adopt a consistent, systematic breeding and culling program.
2. Secure through breeding, management, feeding, and disease control, a high-percentage calf crop.
3. Promote, through feeding and management, normal and continuous growth of young cattle to secure efficient feed utilization and to produce a desirable product.
4. Adopt production and selling policies that will yield the highest return from the annual feed supply.

In the subsequent pages, the application of these rules is presented.

The first step in a constructive breeding program is to get thoroughly in mind an ideal toward which to work. No man breeds better cattle than he knows. The best way to get the desired type in mind is to study outstanding herds, to attend the shows and sales, to observe the kinds that fatten most readily, and to study the types depicted in breed and livestock journals.

The conditions necessary to herd improvement are summarized as follows :

1. Knowledge and judgment on the part of the stockman as to type, conformation, and quality of cattle that use feed most efficiently and yield a product that meets the market demand.
2. A feed supply adequate for the development of the hereditary possibilities of the animals.
3. A high-percentage calf crop, which reduces the number of dry cows to be sold and increases the number of heifers from which replacements may be selected.
4. The breeding of heifers at a stage of development that does not interfere with realization of their hereditary potentialities.
5. The consistent study and selection of bulls and cows and continuous culling to obtain uniformity of type and performance.

SELECTIVE BREEDING AND CULLING

Selection of Bulls.—The responsibility of the purebred breeder is to supply commercial producers with bulls that are uniformly prepotent for siring cattle of the higher market grades capable of converting feeds into beef economically. The value of a beef animal depends upon these two factors: the suitability to market demands, as designated by market grade, and efficiency of feed utilization. Market grade is determined by

conformation, quality, and finish or degree of fatness. Efficiency of feed utilization is determined by the amount of feed required to produce gain. Experiments have shown that rapidity of gain is closely correlated with amount of feed required to produce gain.

Market demand calls for animals in all stages, from veal calves to mature beeves. It is desirable, therefore, that bulls sire offspring that can be finished at any age. Sires that meet these requirements are those rugged, moderate-sized bulls that are thick-muscled, uniformly deep and wide-bodied, low-set, have short necks and broad short heads, and possess smoothness and quality.

The beef animal primarily produces muscle meat. Enough fat is needed to protect the carcass from shrinkage and spoilage while aging and to give tenderness and flavor to the lean. The muscles of the back, loin, and round are especially important. These determine the yield of high-priced cuts and the proportion of meat to bone in cuts most desired by the consumer. The size of the round is largely determined by muscle, only to a minor extent by bone and fat; and it is, therefore, a good index of muscling over the rest of the body. The importance attached to development of hindquarters in judging cattle is based on these facts. Short necks, trim briskets, and smooth forequarters add to the value that the retailer can cut out of the carcass.

Growth of parts of the body does not proceed at the same rate, hence the difference in body proportions of young and mature animals. Although bone, muscle, and fat growth proceed simultaneously, bone growth reaches a peak before muscle growth, and muscle development before fattening. The cannon bone is one of the earliest maturing parts. Its percentage growth after birth is much less than in bones higher in the leg and in the pelvis. Shortness of cannon bones that makes beef animals low-set is an index of early maturity.

These characteristics of conformation must be combined with sturdy constitution and feed capacity, all essential to rustling ability, hardiness, and efficient feed utilization. A short, broad head is indicative of good feeding qualities. Masculinity and breed character are indicative of breeding ability and of prepotency.

Selection should be made from bulls that have been well fed and have had a chance to develop. Underfeeding may not only change the form of an animal, but may also make it impossible to determine the individual's potential ability to make rapid gain.

Closely bred bulls having the type, ruggedness, and other characteristics stressed, are more apt to breed uniformly true to type than distantly related animals. When desirable blood lines have been proved, it

is advantageous to continue them and to select consistently the same type of bulls, in order to secure uniformity in the herd.

The foregoing points are the essential considerations in selecting bulls. Such characteristics as shade of color, color markings, shape and size of horns, are all *nonessentials* as far as the final product is concerned. Uniformity in these respects is, however, attractive to buyers and helps to cover up lack of uniformity in essential characteristics.

Purebred bulls that have been raised under cultivated pasture conditions or other close confinement are in about the same condition for range service as an office worker is to pitch hay. Bulls under these conditions should be purchased in time so that they can become acclimated and adjusted to new feed conditions before service. It is usually more a matter of exercise and "toughening" the muscles than merely reducing fat. Bulls should be well fed and in good active condition when put in service.

Records have shown wide variation in rate and efficiency of gains even among cattle of high quality. Progeny records were obtained on three Hereford bulls in the University herd. Bull "A" sired daughters that averaged 635 pounds at 12 months of age; bull "B" sired daughters that weighed 690 pounds; and bull "C" sired daughters that averaged 730 pounds at a similar age and under the same feed conditions. Records in other purebred herds have shown similar variation in ability of bulls to sire animals of high gaining ability and of high quality. In addition to customary methods of selection and good old-fashioned culling, breeding, based on systematic records of progeny performance, will greatly aid purebred breeders in supplying commercial cattlemen with consistently good breeding bulls. It is comparatively easy for a good breeding bull to increase the value of his calves over the average by five dollars per head.

Selection and Culling of Cows.—Under most conditions in California, improvement in feed and other environmental conditions and better management must go along with selective breeding and culling if the benefits possible through breeding are to be realized. Under extremely rigorous conditions, the plainer, slower-developing animals may actually do better than those bred for rapid growth and early development.

The manner in which the animal grows determines largely the shape and size of the individual and the proportion of meat to bone and fat. A splendidly bred beef animal that has experienced alternate stages of good gains and severe losses in weight will appear entirely different from one of equal breeding that has made continuous growth from calfhood. Since different parts of the body do not develop at the same rate, alterations of conformation may depend on the age at which development was

restricted. "Running out" or becoming "fine-boned" is a common expression for some of these effects. The remedy is more logically applied through supplementing or otherwise improving the feed supply rather than by buying big-boned, rough bulls. A realization of the manner in which animals grow and their reaction to environment can do much to bring purebred breeders and commercial cattlemen closer together in a mutual understanding of their respective problems.

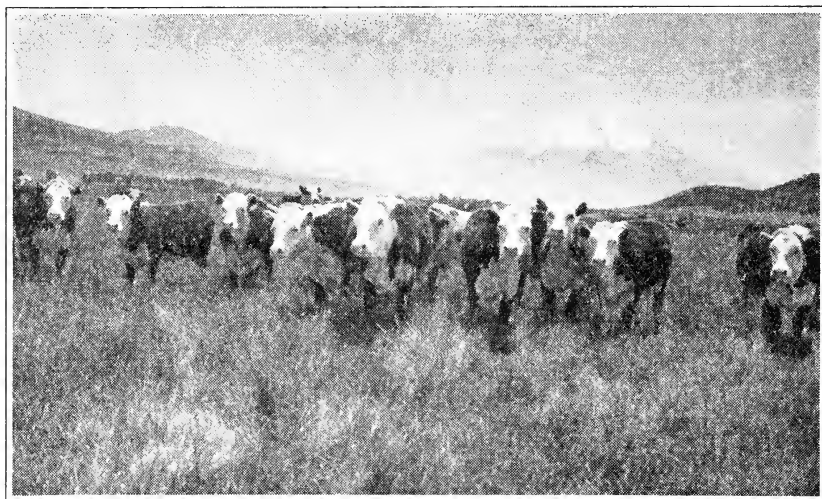


Fig. 12.—Yearling heifers from selected cows and top bulls for herd replacement. They were wintered on 13 pounds mixed hay and $1\frac{3}{4}$ pounds grain per head daily. Their daily gain during the winter was 0.96 pound.

Poor feed means low calf crop and a high percentage of dry cows. If buyers are allowed to pick out the good individuals, if there is automatic culling of all dry cows, if undeveloped heifers are bred, and if *all* heifer calves are required for replacement, then the cow herd may "run down" faster than improvement can be made by good bulls. Although feed supply and disease are the primary factors influencing calf crops, some non-breeders continue to occur in all herds regardless of feed conditions. If feed conditions are adequate, then dry cows usually should be sold. Non-breeders may result from hereditary abnormalities, infections, and injuries in calving. All poor milkers should be culled from the herd. Under inadequate feed conditions most of the dry cows customarily sold are pregnant and would drop calves in a few months, while many cows with calves at side may be the ones due to miss or be late in calving the following year. The practice of culling dry cows under these conditions usually leads to neither increased calf crop nor herd improvement, for many of the best cows are sold and poorer ones are retained in the herd.

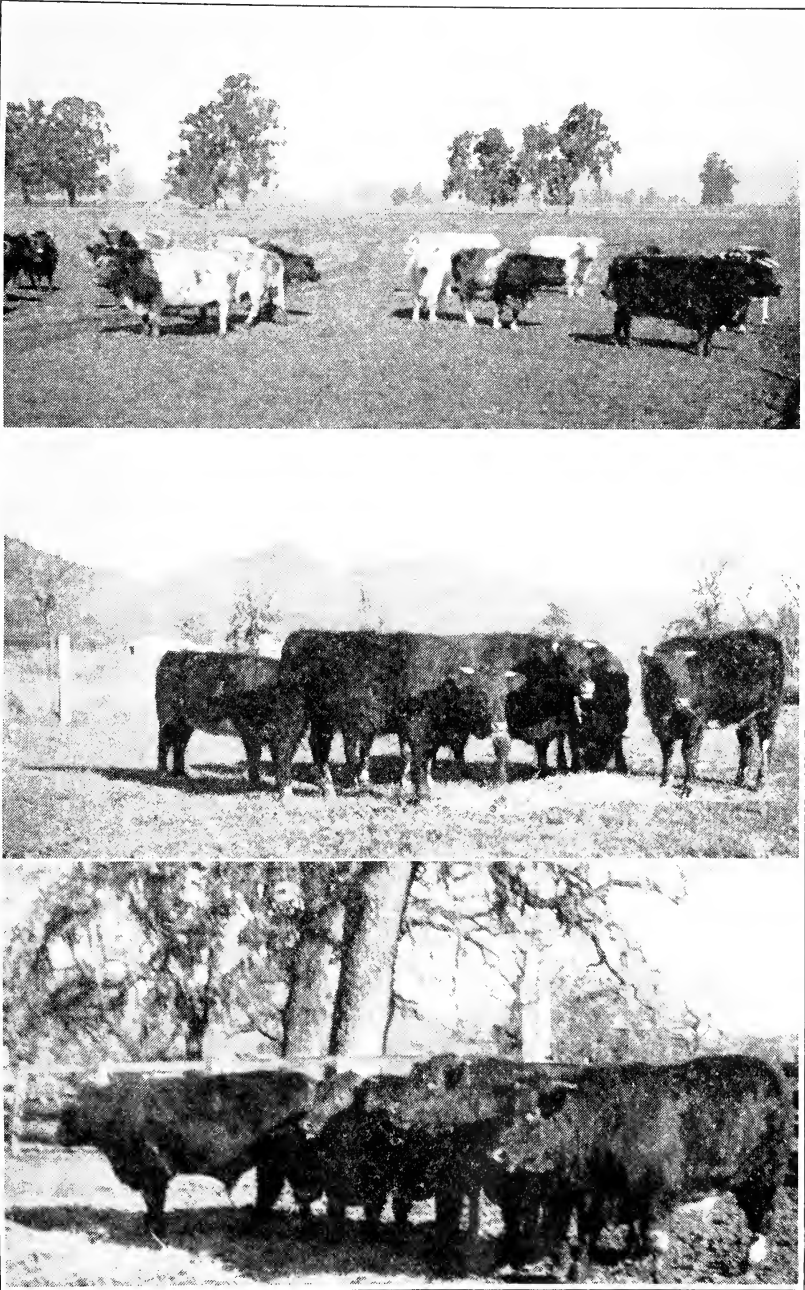


Fig. 13.—Shorthorns of the type shown in each of the above pictures make excellent foundation animals for the production of high-quality feeder cattle which will attain heavy weight for age when good management practices are followed.

When possible to do so, most rapid progress can be made by selecting a sufficient number of the very best cows for breeding to the best bulls to supply the heifers necessary for replacement. Such heifers give greater

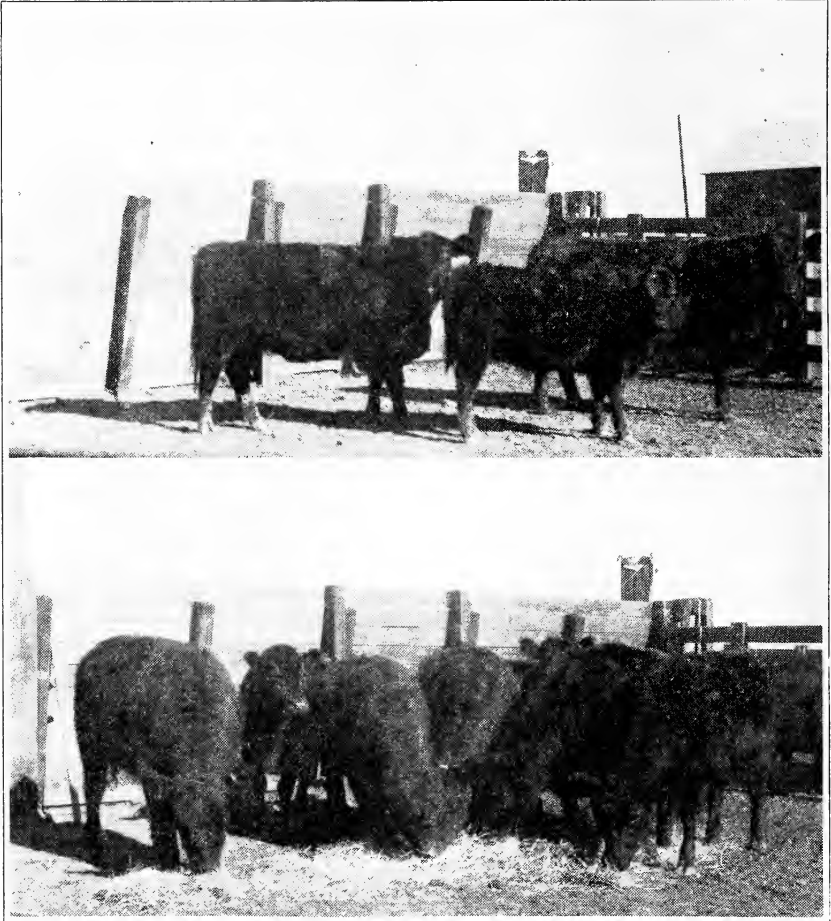


Fig. 14.—Individual performance records are kept on these very desirable Aberdeen Angus females. They have never been pampered but fed only for normal growth. Their depth and thickness is due to natural fleshing. In the upper picture the cow on the right is the dam of the two heifers. The average daily gain from birth has been 1.8 pounds for the 17-month-old heifer on the left and 2.2 pounds for the 6-month-old calf in the center. The seven heifers in the lower picture range from 14 to 17 months of age. Their average daily gain from birth has been 1.5 pounds.

assurance of breeding true. The results of this procedure are shown in figure 12. Weaning time is ideal for selection and culling. The deep-bodied, naturally thick-fleshed cows with good heads that have raised good calves and still maintain thrifty condition are the ones to keep. All

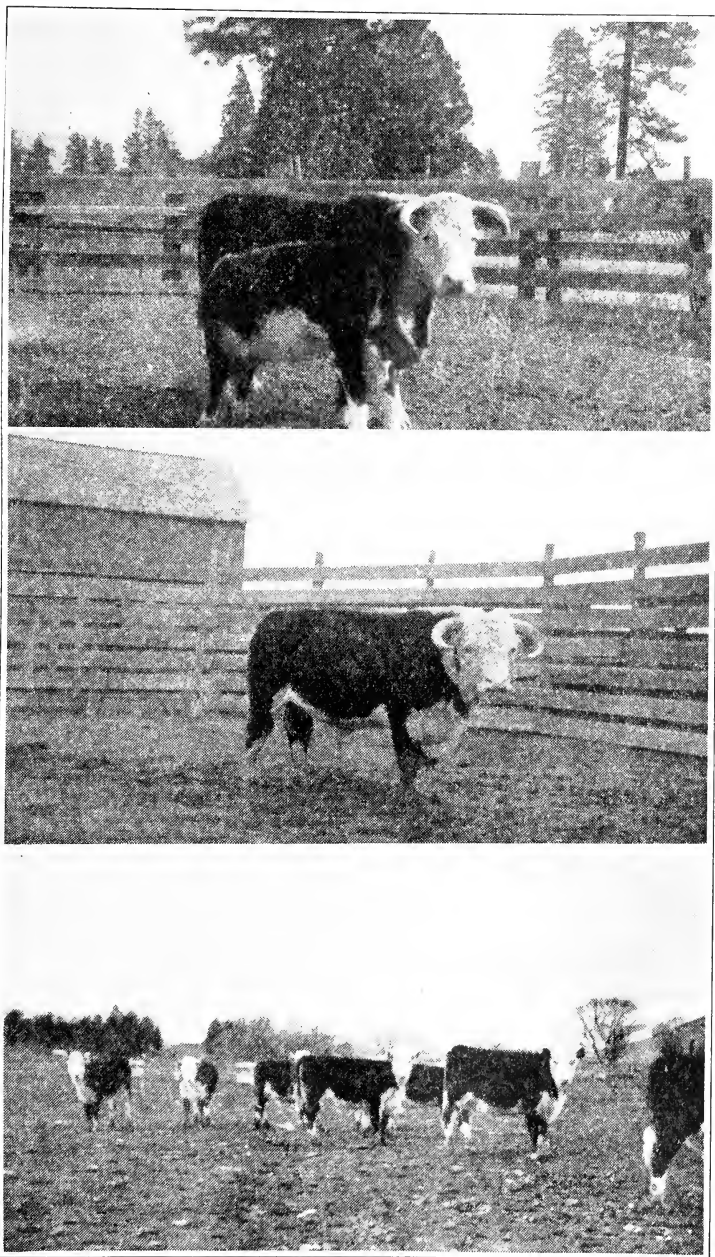


Fig. 15.—These Herefords are the result of selective breeding. The cow at the top provides ample milk for her calf, yet remains in good condition herself. The bull (center) is a proven sire. As a six-year-old he was mated with 50 selected range cows and produced 50 calves like those shown in the lower picture. As a seven-year-old, the bull sired 62 calves under meadow pasture conditions.

long-headed, thin-necked, shallow-bodied, flat-ribbed, "dippy"-loined, light-hind-quartered kinds and old cows should be culled. A herd of quiet, easily handled cattle is a distinct advantage; therefore, selection for these qualities and the culling of wild cows should be practiced. The culled cows may frequently be handled best by placing in a separate pasture to prevent breeding and thus save bull costs. Calves from culled cows may be vealed or kept until weaning time. Calves are commonly vealed in order to sell fat cows. Frequently it may be profitable to raise the calves to weaning even though the cows are sold at a lower price as feeders or low-grade slaughter animals. If held for another season, cull cows consume feed that can be utilized better by more efficient animals. A systematic program of breeding, culling, and feeding as outlined will revolutionize in a few years the quality of an ordinary herd. The effect of selective breeding and culling in herds representing the three principal beef breeds is shown in figures 13, 14, and 15.

PERCENTAGE CALF CROP

Since the primary function of the breeding herd is to produce calves, the breeding, feeding, and management of the cow herd are discussed in this relation. The principal factors controlling calf crop are:

1. The plane of nutrition of the animals.
2. Season of breeding
3. Proportion of bulls to cows and their distribution on the range.
4. Selection of breeding stock by proper culling.
5. Control of infectious diseases affecting reproduction.

Figure 16 shows the variations in weight of purebred beef cows and heifers during the lactation and gestation periods that occurred when abundant feed was available throughout the year. These cows, in high condition, did not change much in amount of body fat. The curves, therefore, reflect largely the changes in weight caused by the developing fetus, membranes, and uterine fluids and the loss at calving time. This emphasizes the fact that pregnant cows must gain about 100 pounds between weaning time and calving time in order to maintain their flesh. The lower curve shows that heifers lose more weight than cows during the first 3 months of lactation. They not only have to regain this loss but have to make additional gain by the time of their second calving if they are to grow and develop normally. This indicates why heifers are more sensitive to feed deficiencies than mature cows and the reason so many heifers fail to breed after their first calving under poor feed conditions.

The poorest feed conditions usually occur between weaning and the next calving time. This is a critical period affecting the next year's pro-

duction. If cows or heifers just maintain weight, actually they lose about 100 pounds in condition, and are thin after calving. Below a certain plane of nutrition, either lactation or reproduction, or both, are impaired. Figure 17 illustrates such effects under range conditions.

Supplemental Feeding of Cows on Range.—The characteristics of the principal types of range forage are discussed in the second part, "Nu-

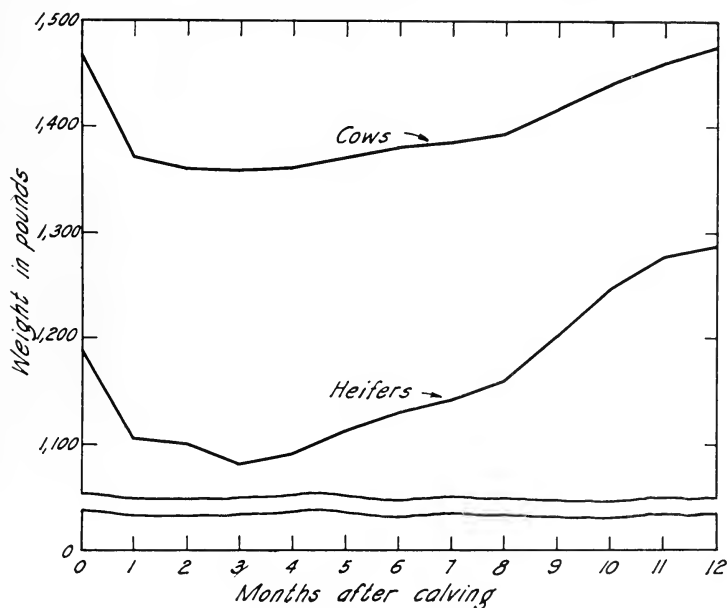


Fig. 16.—Variations in average weight of purebred cows and heifers during the lactation and gestation periods. (Data from: Guilbert, H. R., and Alex McDonald. Weight records on purebred beef cattle during growth, gestation, and lactation, together with data on reproduction. Am. Soc. Animal Production Proc. 1933:244-53.)

trient Requirements and Cattle Feeds." Because of the high-protein and total-nutrient value of bur clover, ranges containing an abundance of this forage will maintain stock in good condition late into the dry season. On most ranges having annual-type forage, bur clover, and other legumes are either lacking or the supply is inadequate to supplement other forage throughout the dry season. On the poorer type of grass-filaree ranges, the cows usually continue to gain through June, maintain weight through July, and begin losing in August. This occurs although forage is abundant and the cows are not suckling calves. On better ranges weight losses coincide with the time when the most nutritious forage has been exhausted through selective grazing and the protein content of the forage eaten falls below 7 or 8 per cent of the dry matter. Protein supplements are, therefore, best for securing effective use of such ranges. Heavy

weight losses occur at the time of the first autumn rains. The feed value of the old forage is reduced by its being leached and beaten into the ground; the new forage is too scant and watery to supply sufficient feed.

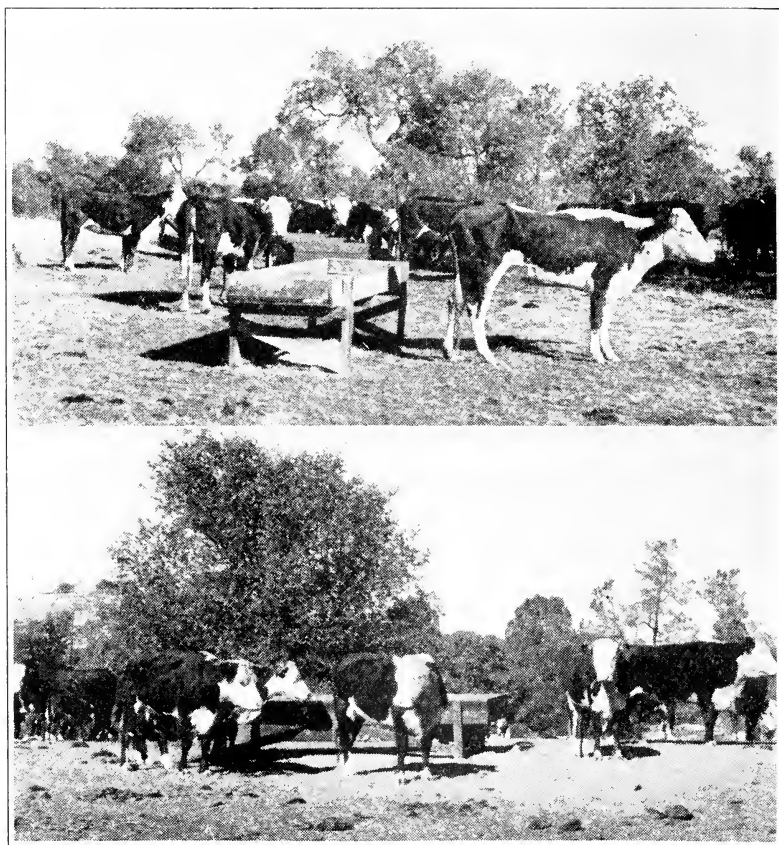


Fig. 17.—The cows in the upper picture lost weight in the fall on range feed alone, were thin after calving, and became weak on continued scant feed. Their calves averaged 386 pounds at weaning time and they produced only a 61 per cent calf crop the following year. The cows in the lower picture were on the same range feed but supplemented with sufficient cottonseed cake and barley to maintain flesh. They produced calves that weighed 481 pounds at weaning time and had a 91 per cent calf crop the following year. (San Joaquin Experimental Range. Photo by M. W. Talbot.)

Greater total nutrients as well as increased protein are needed at this time. When a significant quantity of the new feed develops, adequate protein and minerals may be supplied, although feed value may still be low. The supplement can, therefore, be changed to grains or other carbohydrate feeds at this time if they are cheaper sources of total digestible nutrients than protein feeds. This may be an important means of econ-

omizing when cold weather retards the growth of the new forage for a long period.

Information and suggestions for meeting these conditions are outlined as follows:

1. The objective should be to feed whatever kinds and amounts of feeds that will most economically overcome the existing deficiency and maintain the breeding cows in thrifty condition. Actual amounts will vary according to the type of range and condition of the cattle. Supplementary feeding pays if it is done sufficiently well to produce results.

2. A small amount of supplement fed daily over a longer period results in better range utilization and is more effective than heavier feeding begun late and after weight losses have occurred.

3. Results at the San Joaquin Experimental Range serve as an example of the approximate amounts of supplement and the feeding schedule that may be necessary to maintain high calf crop and to produce heavy weaner calves on the poorer types of grass-filaree range. One pound of cottonseed cake was fed daily during August. From September to the time of the first rains $1\frac{1}{2}$ to 2 pounds daily were fed. At this time supplements were increased to 3 pounds daily and then gradually decreased as new forage developed.

If cold weather results in slow growth of new feed, as much as 5 pounds daily may be necessary for cows that have calved during this period. The total supplements per cow will usually amount to 250–300 pounds when fed as indicated. The resulting increased calf crops of heavier calves, worth more per pound, have yielded good profits on this additional expenditure. On better ranges, the amounts required will be less, or supplements may be unnecessary.

4. When barley and other grains are cheaper than cottonseed cake, the amount of cottonseed cake can be reduced and additional supplements selected from the cheapest sources of digestible nutrients.

5. Feeding double amounts every other day is about as effective as daily feeding and reduces labor. If cows have been taught to eat supplements as calves, no difficulty in getting them to eat will be experienced thereafter. Cattle can be trained to come for feed when called.

6. Feeds like cottonseed cake can be fed on the ground in dry weather. Feed bunks placed at convenient places on the range are, however, preferable. They save waste in feeding, and the operator can use those feeds that are most economical, rather than be limited to a single feed that may at times become exorbitant in price.

7. First-calf heifers and the thinner cows may need extra feed and special care. Where practicable, the segregation of such animals from the main cow herd to allow feeding according to needs increases the effectiveness of supplements used.

A systematic supplemental feeding plan as indicated above provides adequate protein and phosphorus and adds materially to the total energy intake. Such a program results in larger calf crop, heavier calves, shorter breeding season, less trouble in calving, fewer retained placentas, lower death rate, and permits early calving.

On ranges where there is no browse or other source of green forage, a

prolonged dry season may result in vitamin-A deficiency and calf losses. Such losses are especially apt to occur when a short green-feed season intervenes between two long drought periods. Information and recommendations for this special type of supplemental feeding are presented as follows :

1. Nonlactating animals with meager reserves may store in 4 or 5 months on green feed sufficient vitamin A to protect them for 6 to 7 months on dry feed.

2. Lactating animals under similar conditions possibly store less on green forage, and their reserves become depleted more rapidly when on dry forage. Heifers have less storage than cows under similar feed conditions and, therefore, become depleted in shorter time.

3. Cows and heifers may produce weak calves that die soon after birth, or within a few days with diarrhea, without themselves showing symptoms of deficiency.

4. If vitamin-A reserves are depleted during the latter part of pregnancy to the point where the cows are night-blind, premature birth of dead calves results. Because of the usual season of breeding, early abortions of small fetuses are not typical of vitamin-A deficiency.

5. If losses from vitamin-A deficiency are suspected, arrangements for diagnosis can be made through the local Agricultural Extension Service office or a veterinarian. Diagnosis is made by tests on the liver of the fetus and the blood of the mother.

6. Losses from vitamin-A deficiency cease quickly when green forage becomes available or suitable supplements are fed.

7. As an insurance against such losses when range forage dries early, supplements should be given a month or more prior to the beginning of the calving season if cows are bred to calve during the fall and early winter months. Supplementing should be considered regardless of time of calving if the cows have subsisted exclusively on dry forage for 5 to 6 months.

8. Providing the breeding herd with Sudan or other green pasture, when possible, is a practical way of obviating vitamin-A deficiency. Even a few days on such forage will usually carry them over the critical period.

A daily intake of 75 milligrams of carotene during the last month of gestation is sufficient to assure the birth of normal calves from cows whose reserves have been nearly depleted. This may be inadequate for subsequent lactation if new forage is further delayed. This amount of carotene will be supplied by approximately: (a) 15 to 20 pounds of hay containing only traces of green color; (b) 4 to 6 pounds green alfalfa hay that would be called "good" by stockmen; (c) 3 pounds daily of highest quality sun-cured hay containing about 6 milligrams of carotene per 100 grams; (d) 0.8 pound of dehydrated alfalfa meal containing 20 milligrams of carotene per 100 grams.

Since feeding several pounds of hay daily tends to substitute for range feed rather than supplement it by discouraging cattle from grazing, it is generally most practical to use concentrated sources. Dehydrated meal bought especially for this purpose should be analyzed, for carotene, by a commercial laboratory and the amount fed calculated on this basis.

9. Liver oils containing from 2,000 to 20,000 U.S.P. units of preformed vitamin A per gram are available at comparatively low cost and may under some conditions be a cheaper supplement than the sources of carotene mentioned. Such oils are tested,

and their vitamin-A value is stated and guaranteed by the manufacturer. The requirement to assure reproduction in cows whose reserves are almost depleted during late stages of pregnancy is about 30,000 U.S.P. units daily. This will be furnished by:

a) About 15 cubic centimeters (approximately $\frac{1}{2}$ ounce) daily of fish-liver oil containing 2,000 U.S.P. units per gram.

b) About 3 cubic centimeters ($\frac{1}{10}$ ounce) daily of fish-liver oil containing 10,000 units per gram or $1\frac{1}{2}$ cubic centimeters of oil containing 20,000 U.S.P. units per gram.

c) Two ounces of the highest-potency oil in a single dose or one third of this amount fed three times on grain or other feed, should supply sufficient vitamin A to protect against deficiency for a month. This vitamin in oil decomposes rapidly when mixed with other feed, and, accordingly, should be added immediately before feeding.

Results of the effect of supplementary feeding as recommended are illustrated in figure 18.

Wintering Cows on Harvested Roughages.—Information and suggestions, particularly applicable for wintering cows in northeastern California counties, are itemized as follows:

1. The amount of feed required will depend upon the condition of the cattle, the amount of grazing, the severity of the weather, and the method of feeding to avoid waste.

2. Twenty to 25 pounds daily of good quality meadow or alfalfa hay properly fed will produce gains and maintain condition. With lower-quality nonlegume hay, a pound of protein supplement daily is desirable.

3. In case of hay shortage, each pound of grain or other concentrate feed may replace 2 pounds of roughage. Roughage should not ordinarily be reduced below 8–10 pounds daily.

4. Grains are satisfactory concentrate supplements to feed with alfalfa or other legume hays.

5. Three pounds of good alfalfa hay are about equivalent to 1 pound of 43 per cent protein cottonseed cake for balancing low-protein roughages.

6. Cows in strong condition in the fall can be wintered on grain straw that is supplemented with 3 to 6 pounds of good-quality legume hay or 1 to 2 pounds of cottonseed cake. Some forage of bright-green color is recommended to insure against vitamin-A deficiency. If no legume hay is fed with straw, cattle should have access to bone meal, ground limestone, or oyster shell flour.

Although the ideal situation is to keep all animals in thrifty condition, some cows and heifers may be thin at weaning time. These are most effectively fed by separating them from the other cattle, by starting on feed early, and by more liberal feeding.

Planning the Breeding Season.—Cows, kept in thrifty condition through adequate feeding, breed readily and produce a high percentage of calves uniform in age. "Short-aged" or "off-season" calves are undesirable and should be avoided. Even if some sacrifice in calf crop has to be made for one season to adjust the herd to a short breeding season, timed to the feed conditions, the change will pay in the long run. If cows

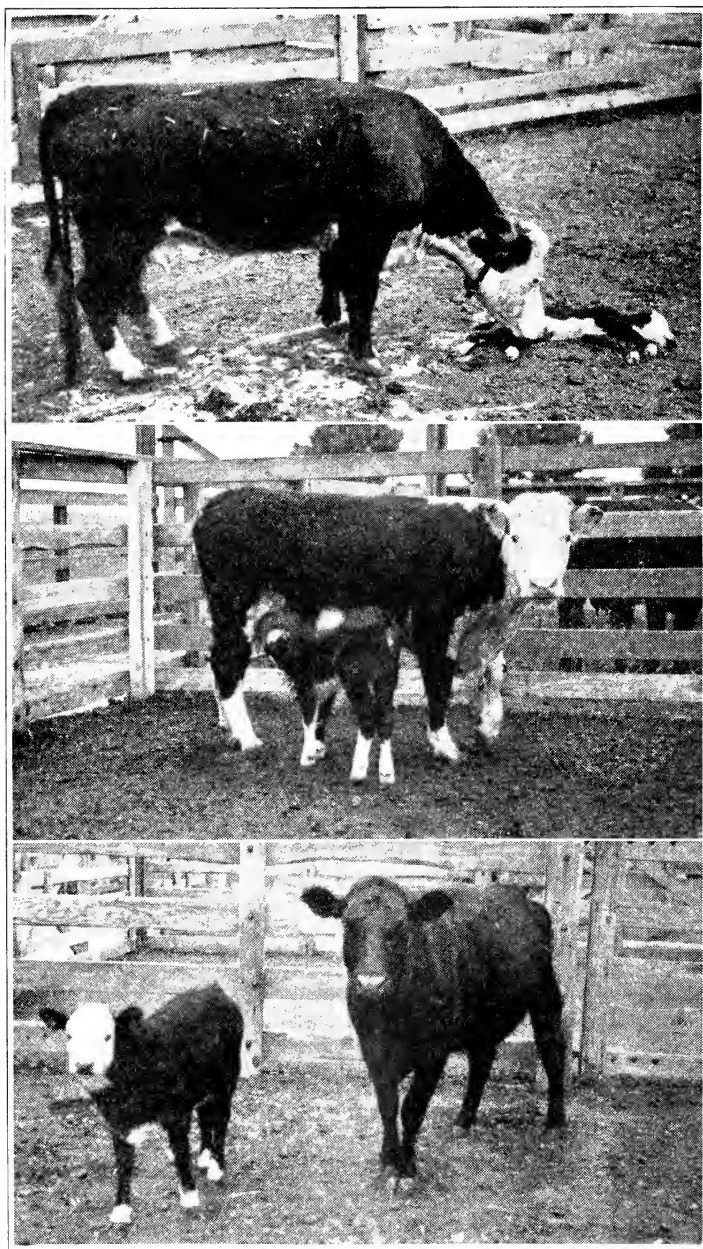


Fig. 18.—The heifer at the top received a ration deficient in vitamin A but otherwise complete; she became night-blind and aborted during the last month of pregnancy. The heifer in the middle picture received the same ration plus 1 pound daily of dehydrated alfalfa meal during the latter part of pregnancy and produced a normal calf. The lower heifer received 15 cubic centimeters of cod-liver oil daily, containing 2,600 units of vitamin A per gram during a similar period; she likewise produced a normal calf.

and bulls are in good condition, a 3 to 4 months' breeding season is sufficient and results in uniform calf crops. This is particularly important in smaller herds from the standpoint of sales, especially of feeder cattle.

In areas with severe winter weather, the calf crop should be timed to come as early as possible and yet escape the danger of late storms. In the northeastern counties the bulls should usually be placed with the herd in June or July.

When operating yearlong on valley or lower foothill ranges, to have calving come in October, November, and December is possible and advantageous when the program of supplemental feeding as outlined is followed. Cows will milk sufficiently well to nourish the calves until new feed is abundant, and by this time the calves are large enough to take advantage of the forage as well as the full milk flow of the cows. Such calves can be weaned in July or August, at a weight of 400 to 500 pounds. They can then continue to gain on dry forage and supplements, and the cows are spared the drain of milking for a long period on dry forage. Most cows will breed late and the majority of the calves will come in the spring unless proper feed conditions have been provided during fall and winter. Spring calves are satisfactory when green forage is provided in the summer by valley or mountain ranges. Such calves are preferred by ranchers having permits on the national forests, partly because calves under 6 months of age are not counted when going into forest range.

Bulls should be acclimated and in good condition when put into service. Bulls from two to six years of age are generally most satisfactory. Older bulls may be used under good pasture conditions. Four bulls for each 100 cows are the usual number used on the range. Under rough range conditions the number should be increased. In a small field of good pasture a mature bull will serve 50 to 75 cows. Under range conditions a good rider who will keep the bulls and cows well distributed is most valuable. On fenced ranges *rotation of bulls* is a practical way of increasing calf crop and reducing the breeding period. Under this system half the bulls are turned with the cows for 10 to 14 days; then these are taken out for rest and extra feeding and fresh bulls turned with the herd. After two such shifts all the bulls can be left with the herd during the remainder of the season.

By breeding under pasture conditions on the home range, by adequate feeding, and by rotating the bulls, some ranchers have decreased the number of bulls required, have used the extra money to buy better bulls, have increased the calf crop, and have had a high percentage of calves dropped within a range of 6 weeks' time.

Diseases Affecting the Calf Crop.—Contagious abortion, commonly

called Bang's disease or *Brucella* infection, is the most common infectious cause of calf losses. This disease is characterized by abortion of fetuses from early to late stages of pregnancy and placentas are commonly retained. Diagnosis is made by means of a blood (agglutination) test. Infection is spread largely through contamination of feed and water by discharges from cows—rarely by bulls. Veterinary advice should be secured regarding diagnosis and control measures, including vaccination. Only a small percentage of cows abort the second time under range conditions. Some cows carrying and spreading infection do not abort at all. Culling out all known aborters under these conditions and replacing them with susceptible heifers may keep the disease active rather than build up herd immunity.

Trichomoniasis is a venereal infection transmitted by the bulls. It is characterized by very early abortions of decomposed fetuses. Frequently vaginal discharge and recurrence of "heat" in cows thought to be pregnant are the only signs of this disease. It is difficult to diagnose definitely under range conditions. Disposal of infected bulls is the principal remedy.

Occasional abortions are caused by *Vibrio foetus*, but this disease is not ordinarily important and is self-limiting.

Veterinary advice should be sought in dealing with any of these disease problems.

GROWTH AND DEVELOPMENT OF FEEDERS

The Principle of Continuous Growth.—An animal is similar to a machine or a factory in that it is most efficient when operating at full capacity. Even under ideal conditions a large part of the total feed eaten is used for maintenance. The value of the practice of feeding for continuous growth is illustrated in figure 19.

The steers fed for maximum gain had access to good pasture along with the mothers until weaned, then were fed grain on pasture to promote rapid gain and finish. They weighed 900 pounds in less than 14 months and were "Choice" slaughter cattle. This method of feeding is practical where a breeding herd is maintained under farm conditions with forage and grain plentiful.

The curve which illustrates limited supplements fed represents a practical approach to the ideal under poor range conditions. A little more than 300 pounds of total supplemental feed permitted these steers to make continuous gains from weaning to the next grass season and to attain a weight of 900 pounds and fleshy feeder condition in 21 months.

The third curve represents steers that had the same breeding and

same range feed as those fed supplements, but they received no supplemental feed. They made no gain during the 6-month period from weaning until the next grass season, though dry forage was plentiful. They gained rapidly on good feed only to lose heavily again under adverse feed conditions. It is obvious that these steers that gained and lost and required 31 months to reach 900 pounds, ate much more total feed than those that required only 14 or 21 months to attain the same weight. They

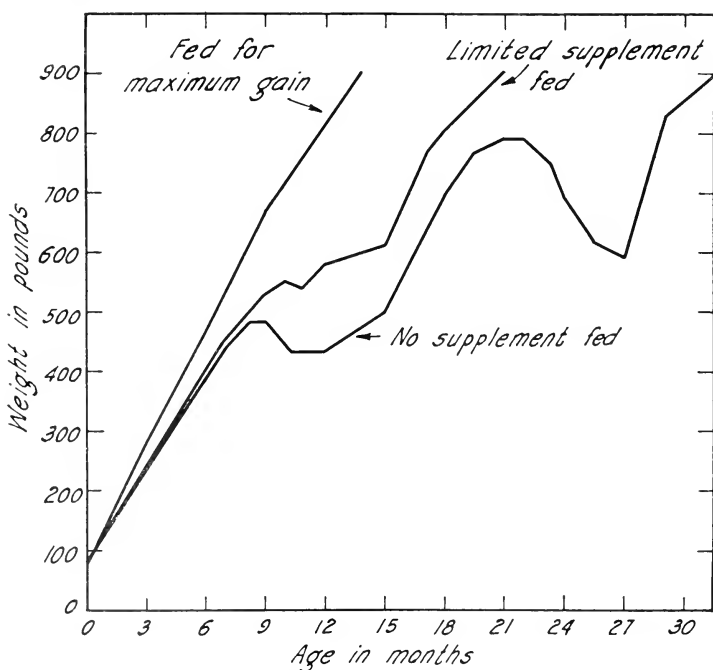


Fig. 19.—Growth curves of steers showing the variation in time required to reach a weight of 900 pounds as determined by feed conditions.

not only required more feed but also incurred added interest, risk, and other costs and yielded a product of lower value.

The dry season or the winter season is usually the most expensive period as far as cost of producing gains is concerned. It is important to secure results so that cost per pound is reduced to a minimum. Calves or yearlings that make good gains during the winter or dry season will gain somewhat less during the subsequent grass season than cattle that make no gain or lose weight. The problem is to secure economical gains during the high-cost period without subsequently minimizing cheap pasture gains. Numerous tests have shown that a gain of about 1 pound daily permits normal development, retains flesh and thrifty condition, and yet

does not detract materially from subsequent pasture gains and results in heavier cattle worth more per pound because of their higher condition and bloom.

The production of about 1 pound per day for calves that are to be sold as feeders at the end of the next grass season is a sound objective. If steer calves are to be finished as long yearlings by feeding on grass, 1½ pounds daily during the winter are desirable. Yearlings that make such gains are in condition to finish on grass under favorable conditions.

Supplemental Feeding of Calves and Yearlings on the Range.—Suggestions for meeting the above-mentioned objectives under range conditions are as follows:

1. Teach the calves to eat supplements while in the corral at weaning time. Unless green pasture or excellent-quality dry forage is available, continue supplemental feeding when the calves are turned out on pasture.

2. On most dry range forage, 1 pound daily of cottonseed cake or its equivalent in other protein feed will continue gains until rains have leached out the forage. It may be necessary to increase the supplement allowance to 2 or 3 pounds daily for the period when the old feed is spoiled by rain and new forage is scant. Decrease the allowance as feed improves and discontinue when the new feed will produce gains. Protein supplement can be held at 1 to 1½ pounds and grains substituted for the remainder of the feed if cheaper. Illustrations of the results of this system of feeding are shown in figure 19. Steer calves fed in this manner weigh about 600 pounds in the spring and 850 to 900 pounds at the end of the next grass season. Heifers will be somewhat lighter in weight.

3. To finish with a short feeding period on grass as long yearlings, more liberal feeding (3 to 4 pounds daily) during the fall and winter may be necessary. Feeding of concentrates on the early green forage may in some cases be a practical procedure for speeding up gain while native feed is watery and may be continued throughout the green-feed season.

4. For moderate growth of yearlings on dry feed 1½ pounds of cottonseed cake daily suffices until the first rains. Subsequently, the feed required to continue gains and maintain condition is similar to that outlined for calves.

5. Utilizing foothill and valley range during the winter and spring and providing irrigated summer pasture or good mountain range are practical ways of continuing normal gains in young cattle and of decreasing the time when supplements are required.

Wintering Weaners and Yearlings on Harvested Roughages.—There is no class of cattle that responds more profitably to liberal feeding than calves during their first winter. It is much more important that calves be wintered well when they are to be sold as fleshy yearling feeders than it is when all cattle are sold as aged grass cattle or hay-fed beef. Often calves are allowed to remain too long with the cows in the fall, or feeding is not begun immediately at weaning time; consequently they lose weight and bloom. Liberal feeding beginning at weaning time is essential for

best results. The protein and total digestible nutrient requirements for growing calves and yearlings are shown in table 4. Feeding practices that have proved profitable and which should produce $\frac{3}{4}$ to $1\frac{1}{2}$ pounds of gain daily are itemized as follows:

1. Provide well-drained corrals or other feeding places where the cattle have wind-breaks and can find a dry place to lie down. Gains are difficult to obtain on young cattle even with abundance of feed unless they can be reasonably comfortable and can rest. In dry cold weather little shelter other than wind breaks is necessary. Favorable feeding conditions are as important as adequate feed.



Fig. 20.—These yearling steers when weaned at 8 months of age averaged 546 pounds in weight. They were fed an average daily ration of 12 pounds mixed hay and 2.5 pounds grain per head during the winter in which period their average daily gain was 1.3 pounds per head. Here they are on meadow pasture without grain and held for fall sale as "Choice" feeders. Note that proper care and feeding make gentle cattle.

2. Clean out mangers of the feed racks frequently to prevent waste in feeding and to provide fresh feed to induce optimum consumption.

3. Calves when allowed all they will eat of high-quality legume hay or mixed hay containing one half of legumes will produce moderate gains under favorable conditions. The amount of hay varies with the size of the calves; from 10 to 15 pounds daily is the usual range in amounts.

4. With low-protein nonlegume meadow hay or grain hay, feed, in addition to all the hay they will eat, $\frac{3}{4}$ to 1 pound daily of cottonseed meal or its equivalent.

5. For gains of more than 1 pound daily, 2 pounds of concentrates in addition to all the roughage the calves will eat, are recommended. With legume hay, grain is satisfactory; with nonlegume hay, 1 pound each of high-protein feed and of grain is recommended (fig. 20).

6. Ten to 15 pounds of silage daily along with all the legume hay that the calves will consume (8 to 10 pounds) makes an excellent wintering ration that produces good gains without concentrate supplement.

7. Calves wintered as indicated should weigh 500 to 600 pounds in the spring and 800 to 900 pounds at the end of the following pasture season.

8. Calves turned out on scant, early spring feed and given hay in addition frequently shrink. In their desire to get the fresh feed, they commonly do not eat much hay and fail to get sufficient feed from the pasture.

An example of the effect on appetite, rate, and economy of gain resulting from using a protein supplement with low-protein roughage is shown in table 10 by the calf-wintering tests at the Nebraska Agricultural Ex-

TABLE 10

RESULTS OF FEEDING CONCENTRATE SUPPLEMENTS WITH HAY FOR WINTERING CALVES

	Valentine, Nebraska* (average of two trials, 10 head per lot)		North Park, Colorado† (average of two trials, 32 head per lot)	
	Lot 1	Lot 2	Lot 1	Lot 2
Winter period—feeding hay with and without supplement				
Number of days in feeding period.....	180	180	150	150
Average initial weight, pounds.....	440	438	408	410
Average final weight, pounds.....	480	606	522	584
Average total gain, pounds.....	40	168	114	174
Average daily gain, pounds.....	0.22	0.93	0.76	1.16
Prairie-grass hay consumed daily, pounds.....	11.6	13.4	....	....
Pounds prairie-grass hay consumed per 100 pounds gain.....	5,204	1,442	....	....
Mountain-meadow hay consumed daily, pounds.....	....	....	14.7	14.5
Pounds mountain-meadow hay consumed per 100 pounds gain.....	....	....	1,939	1,257
Cottonseed cake consumed daily, pounds.....	....	0.75	....	0.8
Pounds cottonseed cake consumed per 100 pounds gain	....	80	....	73
Summer period—grazing without supplement				
Number of days in period.....	150	150	159	159
Average initial weight, pounds.....	480	606	522	584
Average final weight, pounds.....	734	816	770	804
Average total gain, pounds.....	254	210	248	220
Average daily gain, pounds.....	1.69	1.40	1.56	1.38
Total winter and summer gain.....	294	378	362	393

* Brouse, E. M., and M. Sherman. 180-day calf wintering project. Nebraska Agr. Exp. Sta. (Valentine substitution) mimeographed reports. 1930 and 1931.

† Rochford, L. H. Summary of six range calf wintering tests. Colorado Agr. Exten. Service mimeographed report. 1931.

periment Station. The hay used in these tests contained only 5.5 per cent protein. The addition of $\frac{3}{4}$ pound daily of cottonseed cake to the ration increased hay consumption, produced over four times as much gain, and 80 pounds of cottonseed cake saved nearly 2 tons of hay for each 100 pounds of gain produced. Moreover, these calves averaged 82 pounds heavier at the end of the next grass season.

In the Colorado trials shown in table 10, cottonseed cake was fed as a

supplement to palatable meadow hay containing 8.5 per cent protein. Cottonseed cake did not increase the consumption of this hay and increased the rate and economy of winter gains to a less extent than in the Nebraska trials.

In both sets of trials the cattle that received no supplement made greatest gains during the summer. The combined difference in total winter and summer gains in favor of the cattle fed supplements averaged 84 pounds in the Nebraska experiments. In the Colorado experiments, the difference in gain during both periods was only 31 pounds; but the cattle fed supplements showed more bloom and were appraised higher at the end of the summer period than those wintered on hay alone. Since calves are usually not sold at the end of the wintering period, the real test of the profit from supplemental feeding is measured by the difference in weight and sale value at the end of the next grass season.

Yearlings may be wintered satisfactorily on the same types of feeds as suggested for calves except that larger amounts are required. There is less need for supplement other than for minimum protein, and more of the coarser feeds may be employed.

ADJUSTMENT OF CATTLE NUMBERS TO FEED SUPPLY

One of the most important problems that confronts cattle breeders and graziers is adequate provision for seasonal and annual variations in the feed supply. Adjustments to meet the situation must differ with individual ranches. The following suggestions, however, have proved practical for wide application :

1. Provide for a proper balance between summer and winter feed supply. This is as essential when cattle are maintained on a single ranch unit as when winter feed and summer feed are supplied by separate units.
2. Stock the ranges moderately so that ample forage is available in average years for maximum gains, without leaving excess forage waste through nonuse.
3. Build up a reserve of hay and other feeds in good years and times of low prices to meet drought and other extreme conditions.
4. Maintain the reserve of fat obtained on breeding cattle in good years through the average years so that some weight losses can be withstood in poor years without interfering with future production.

On ranches that normally carry cattle yearlong on the range without hay feeding, the building up of a hay reserve of at least one-half ton per animal unit is advantageous. Such a reserve of hay is a cheaper insurance against the extreme feed shortage that sometimes occurs than stocking so lightly that sufficient dry feed remains on the ground for the emergency of delayed fall rains. Dry feed is spoiled by rains and wasted from non-

use during average years while the hay under shelter can be kept for many years without significant loss of value. This policy permits as complete use of the range as is consistent with its conservation and results in higher returns in pounds of beef per acre without gambling on the drought years. In some areas silage is an excellent feed to reserve for emergencies.

The effect of trying to increase numbers over the feed supply was strikingly shown at the New Mexico Experiment Station. Under adequate adjustment of cattle to feed, cows averaged about 1,000 pounds in weight; the calf crop was about 90 per cent, and the calf weight at weaning about 400 pounds. When the same amount of feed was consumed by 30 per cent more cattle, the cows weighed from 650 to 700 pounds; the calf crop was about 40 per cent, and the weight of calves 300 pounds or less. In the first case it was estimated that 30 per cent of the feed went for calf production and 70 per cent for maintenance; in the latter, 90 per cent of the total feed was used for maintenance and only 10 per cent recovered in production.

MANAGEMENT PRACTICES

Dehorning.—The advantages of dehorning are as follows:

1. Dehorned cattle require less feeding space in feed lots, feed more quietly, and there is less fighting away from feed, of timid animals.
2. Dehorned cattle require less space in shipment and are less apt to bruise and injure one another.
3. Dehorned cattle present a more attractive and uniform appearance.

For all these reasons there is price discrimination against horned animals both as feeders and as slaughter cattle. The disadvantage of dehorning is the labor of performing the operation and the set-back to the cattle. The younger cattle are when they are dehorned, the less they are affected by the operation. In one test, when yearling cattle were dehorned after arriving at the feed lot, 15 days were required for the animals to attain the weight they had before dehorning; thereafter gains were normal.

On California foothill and valley ranges where fall and early winter calves are practicable, dehorning can be done in January and February when the danger from blowflies is least. This is a further advantage of early calves in these sections. Younger calves having "buttons" or small horns that have not attached solidly to the head may be dehorned with caustic. Either stick caustic or paste may be used, though the latter is usually preferred. Directions for using the caustic paste are supplied by the manufacturer. Some operators cut off the larger horns (up to about 1½ inches long) with a knife or with the spoon gouge and lightly apply

caustic to the wound. This has a cauterizing effect and destroys any horn cells not otherwise removed. If a careful job is done with the "spoon" gouge, however, caustic is unnecessary and its use delays healing.

For dehorning calves or yearlings with larger horns various types of clippers or dehorning saws are used. In either case a one-fourth to one-half inch circle of skin should be removed with the horn to insure a smooth poll. If the horn is taken off close to the head, bleeding can be reduced to a minimum by pulling the two arteries lying between the skin and the bone on either side of each horn. For this operation sharp-nosed pliers are used. In pulling the artery, about one-half inch is removed, leaving a crushed end underneath the skin. With a little practice and suitable pliers, this can be done in a few seconds. Various powders and liquid applications are offered by livestock-supply companies that are more or less effective for reducing bleeding and repelling flies. If there is no fly danger, and instruments are kept sterile by dipping in disinfectant between operations, treatment of the wound is usually unnecessary.

When, on account of danger of maggots, dehorning cannot be done when the calves are very young, it is commonly delayed until the following winter or spring.

If wounds become infested with blowfly maggots or screwworms, the maggots can be killed with benzol, removed with swabs and forceps, and the wound treated with fly repellent. Pine tar and bone oil are common ingredients of such preparations. Castor oil poured into the wound is very effective in promoting healing and has some fly-repellent properties.

Adequate equipment, such as the chute shown in figure 21, or a calf-marking table, results in better work and is much easier on men and animals than roping, "flanking," and "mugging." The use of extra time to do careful work is more profitable than setting records for the number of cattle worked per hour.

Castration.—Bull calves can be castrated at any time when they are from a few weeks to 7 months of age. It is preferable, however, to castrate before they are 4 months old; if deferred until after 7 months, they will tend to show some stagginess. As with dehorning, there is less hemorrhage and set-back with younger than with older animals. The usual method is to cut off the lower third of the scrotum, slit the membrane covering each testicle, force out the testicles, and sever the cord by scraping with a knife. The hands of the operator and the knife should be kept clean and as nearly sterile as possible by dipping into a disinfectant solution between operations. The wound should likewise be disinfected. Chlorazene solution or weak solutions of sheep dip, lysol, or similar preparations are satisfactory. Danger of maggot infestation must be con-

sidered as in dehorning. Castration by crushing of the cords without severing the scrotum using burdizzo-type instruments has the advantage of avoiding blood loss and maggot infestation. If carefully done, this method is satisfactory. In actual practice a higher percentage of cattle show some stagginess when this method is used than when castration is done with the knife.

Vaccination.—Blackleg immunization through vaccination is an almost universal practice. Immunity should be established as early in life as possible. On ranges of lower altitude calves are commonly vaccinated when they are castrated and branded in the late winter or early spring. In later-calving areas, calves are usually vaccinated at marking time and before going to summer range. Although outbreaks may occur at any season of the year, the greatest danger is in the spring and fall months. Single doses of modern vaccines immunize for life. Detailed directions for vaccination are supplied by biological companies manufacturing the vaccines.

In anthrax-infected areas, routine vaccination is necessary. Veterinary service should be employed in all anthrax outbreaks.

Branding.—All brands and marks must be approved and recorded by the Livestock Identification Service, California State Department of Agriculture, Sacramento. To avoid unnecessary damage to hides and to the animals, brands should be as small as is consistent with ease of identification. Since the brand increases in area with growth of the cattle, small brands may be used when calves are branded at a few months of age. Hot-iron branding is most commonly employed and in general is most satisfactory. Cold-iron branding, using caustic branding fluid, causes the animal very little pain and when carefully applied makes a permanent brand in the skin. It does not change the direction of hair growth as does the hot iron and for this reason becomes illegible when the hair grows out. Caustic branding fluid is not, therefore, recommended for general range use. Whenever possible it is desirable to brand, castrate, dehorn, and vaccinate before the calves are 4 months of age and while with their mothers. A satisfactory and inexpensive type of chute and squeeze for dehorning and branding is shown in figure 21.

Weighing Cattle.—A set of scales is a good ranch investment, not only for use when making sales, but also for weighing cattle kept on the ranch. Weighing different classes of cattle at the beginning and end of the pasture season, dry season, or winter period gives the stockman a definite basis upon which to plan feeding practices, supplemental feeding and selling policy. Weights can usually be taken when cattle are brought to the corrals for other purposes. Because of great variations in "shrinks"

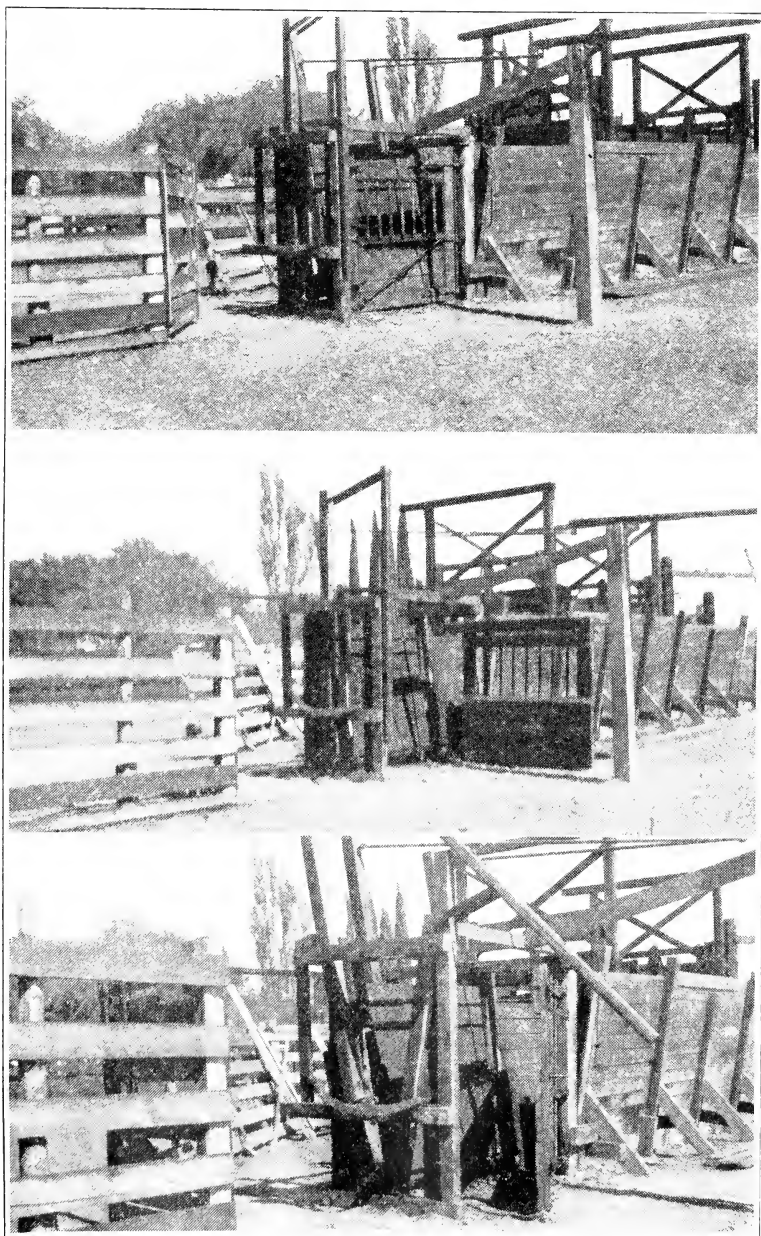


Fig. 21.—This cattle chute and squeeze is adapted from what is known as the Nevada low-cost dehorning chute. The body squeeze and neck squeeze operate in the same manner as in other types of chutes. The distinguishing feature is the absence of a front exit; the animals leave the chute through one side which is hinged and operates as a side gate.

and "fills" apparent gains or losses over short periods are not very reliable. Cattle should be weighed as nearly as possible under the same conditions each time to obtain reliable data. Steer and heifer weights should always be obtained and recorded separately because of the differences in gains usually made by the two classes.

SELLING POLICY

Basic information for determining selling policy is presented in the first part, "Status of the Industry." Cost records over a period of years for the individual ranch, coupled with information on market demand, constitute the best basis to determine the age to market and whether to finish cattle or to sell them as feeders.

In general, cost-of-production records on breeding ranches show that the total pounds of beef produced from a given amount of feed are greatest where cattle are sold at the yearling stage. Because of the overhead charge of the breeding herd, calf cost per hundred pounds at weaning time is usually greater than for the same animal a year later. Total ranch production, in the form of two-year-old feeders, is usually less than if all the surplus is sold as yearlings and a larger breeding herd kept. The price of calves, compared with yearlings and two-year-olds, and of feeders compared with finished cattle in relation to total tonnage of beef produced, must be considered to determine the best means of marketing the ranch feed supply.

Practical sorting of cattle before offering for sale should be a part of the selling policy whether the animals are sold at home or elsewhere. The wider the variation in quality and weight of the sale cattle, the greater the need for sorting. A single buyer is always more attracted to well-sorted loads of cattle. If several buyers are in the field, sorting is still more advantageous. This same principle applies to weight variations. The buyer who is seeking a uniform lot of top-quality cattle will discount his bid if inferior animals are included in the offering. On the other hand, the buyer who is satisfied with plain cattle may pay the full market price for that kind, but little if any premium for top-quality cattle offered to him. This same principle applies in sorting cattle according to weight.

FATTENING CATTLE

Proper adjustment between feeds to be used, cattle to be fed, and feeding practices to be employed is of utmost importance in fattening cattle, because this is the most expensive stage in beef production. These points are outlined in more detail below :

1. Feed, whether it is raised or purchased, is the greatest item of cost and one over which the feeder can exercise considerable control. For best results rations should possess: (a) Quality in each feed, for maximum digestibility; (b) balance of feeds, to supply adequate protein, minerals, and vitamins; (c) variety, to assure provision of all required nutrients and palatability; (d) economy, to permit profit.

2. On good-quality rations, younger cattle use less feed to produce gain and make cheaper gains than older cattle. Calves, when properly fed, require but 65 to 75 per cent, and yearlings 75 to 85 per cent as much feed to produce gain as do two-year-olds of the same type and grade fed in a similar manner.

3. To meet Pacific Coast market demands, calves require a fattening period of 5 to 7 months; yearlings, 3 to 5 months; and two-year-olds, 2 to 4 months. The total gain required for finishing calves is 300 to 450 pounds; yearlings, 225 to 350 pounds; and two-year-olds, 125 to 250 pounds.

4. Steers make slightly more gain than heifers. Heifers, however, fatten faster than steers. California markets do not demand as high a degree of finish on heifers as steers; therefore, a shorter feeding period is required for the heifers. Spayed heifers do not make more economical gains than open heifers, nor do they excel in dressing percentage.

5. Well-finished heifer calves and yearlings slaughtered at 750 pounds or less yield as well as steers of comparable age and grade, and show little, if any, more carcass waste than the steers. The carcasses of heavier and older heifers are usually more wasteful than those of steers comparable to them in age and finish. The quality and palatability of heifer beef are equal to those of steer beef.

6. Feeder cattle of high quality have wider adaptability than those of poor quality. A good general rule is to feed the most of the best feed to the best cattle.

7. Two- and three-year-old cattle, and good-quality early maturing yearling heifers may fatten on pasture without the aid of concentrate supplements. Yearling steers will gain rapidly on good pasture but rarely fatten unless concentrates are fed. Where it can be practiced, pasture fattening, aided by supplements when necessary, usually results in more economical gains than feed-lot feeding.

8. Creep-feeding is a profitable practice under certain conditions. Well-bred, properly creep-fed calves attain a weight of 700 to 800 pounds and desirable market finish at 10 to 12 months of age.

9. Careful attention to feeding practices is fully as important as right selection of feed and cattle. Proper sorting of cattle, correct preparation of feeds, regularity of feeding, and contentment of animals, often mean the difference between profit and loss.

10. The necessary margin or spread between the feeder value and the selling price of the animals when fat depends largely on the relation between feed prices, cattle prices, and amount of feed required to produce gain.

Five general feeding rules should be kept in mind :

1. Three and preferably four or more feeds should be included in feed-lot rations.
2. Fattening cattle will consume daily $2\frac{1}{2}$ to $3\frac{1}{4}$ pounds of dry feed or its equivalent for each 100 pounds animal weight.
3. For rapid gain and finish, calves require $1\frac{1}{2}$ to 2 pounds of concentrates for each 100 pounds live weight, and yearlings, 1 to $1\frac{1}{2}$ pounds. Two-year-olds on good-quality pasture or roughage may fatten rapidly without concentrates; but in the feed-lot when fed for rapid finish, they need 1 to $1\frac{1}{2}$ pounds concentrates for each 100 pounds live weight.
4. When good-quality legume hay as the sole roughage constitutes 50 per cent or more of the total feed, and carbonaceous concentrates the remainder of the ration, protein concentrates such as cottonseed cake are not required to balance the ration. When strictly nonlegume hay is used, a protein concentrate should constitute 7 to 8 per cent of the total ration, or be fed at the rate of 2 to $2\frac{1}{2}$ pounds for each 1,000 pounds live weight.
5. No protein concentrate is required when cattle are fattened on green pasture. On dry pasture containing bur clover 1 to 2 pounds of cottonseed cake, or equivalent, for each 1,000 pounds live weight is recommended. On dry pasture with no legumes the amount of protein concentrate should be increased by feeding $2\frac{1}{2}$ to 3 pounds for each 1,000 pounds live weight.

These rules are for general guidance only. Tables 4, 8, and 9 and information on characteristics of feeds discussed in the second part, "Nutrient Requirements and Cattle Feeds," may be consulted for checking on feed requirements of cattle, on balance with respect to protein, minerals, and vitamins, and for selection of the most economical rations.

RATE AND ECONOMY OF GAIN

Ration, age, sex, type, and grade of cattle, length of feeding period, feeding practices, and weather, all influence the rate and economy of gain which in turn is of greatest importance in both pasture and feed-lot fattening of cattle.

Ration.—Since feed is the greatest item of cost in fattening cattle, very careful thought should be given to the selection of a ration that will meet essential requirements.

Quality of feeds: Digestibility and palatability must both be considered in determining the quality of feeds in the ration. While low-quality feeds can often be marketed to advantage through cattle, it is usually advisable to depend on stock cattle or mature fattening cattle to utilize such feeds. Seldom will it pay to include low-grade feeds in the fattening ration of calves. Such feeds as grain straw, coarse stemmy hay, and light-weight barley are high in fiber content and unpalatable to cattle. If low enough in price, they may be used in the fattening rations of older

cattle, provided highly digestible and palatable feeds are included in the ration.

Variety : Total feed consumption depends not only on palatability but also on completeness of the ration. If deficient in essential nutrients, only small amounts will be consumed, although the ration may contain such palatable feeds as beet pulp and molasses. If animals become tired of a ration it is evidence of deficiency. Single-plant sources do not furnish all essential nutrients, as evidenced by the fact that cattle fattening on pasture prefer a variety of forage. The best practical method of assuring a complete ration is to furnish a variety of feeds. Variety is more important in rations for young cattle than for older ones. Calves and yearlings held on feed for several months often tire of rations lacking variety, and rate of feed consumption and gain is thereby retarded. Good-quality rations, possessing variety, decrease digestive disturbances, and promote more uniform finishing of cattle.

Balance : The nutritive ratio or proportion of digestible protein to digestible carbohydrates and fats is important in fattening rations. The primary function of the protein is to repair and build muscle tissues. The carbohydrates and fats in excess of heat and energy requirements produce fat. More carbohydrates and fats in proportion to protein are required for the fattening process than for growth. Young fattening cattle require more protein in their rations than do mature cattle because they are growing as well as fattening. The desired nutritive ratios for fattening cattle of different weights and ages are shown in table 4.

Protein concentrates, such as cottonseed meal, are usually higher in price than the grains and other carbohydrate feeds. Many feeders increase their costs unnecessarily by feeding more protein concentrates than required for rapid and efficient gains. To the extent that additional protein is needed to properly balance the ration, the protein concentrates return a value well above that of grains or grain substitutes. Once the ration is balanced, carbohydrate feeds promote fattening more efficiently than do protein concentrates. Trials at the Arizona Agricultural Experiment Station showed that 100 pounds of cottonseed meal were required to equal 95 pounds of barley when used in excess of protein requirement and as a substitute for the grain. Gains were practically identical for the lots compared.

If the excess protein included in many fattening rations were used to supplement stock cattle for maintenance and growth, far greater returns would be shown for this valuable feed constituent.

Mineral and vitamin requirements must also be recognized in properly balancing rations. Mineral deficiencies are not likely to occur in ordinary

fattening rations used in California. Cattle are usually given access to salt, the grains in the ration and protein concentrates such as cottonseed meal supply adequate phosphorus, and the roughages furnish the needed calcium. Beet by-products are deficient in phosphorus. Where a heavy ration of beet pulp and molasses is fed with little or no grain, or no protein concentrate is used, phosphorus deficiency will occur. Calcium deficiency rarely occurs in feed-lot rations except where calves are fed heavily on concentrates, or on concentrates and silage and small amounts of non-legume hay. Under certain conditions, fattening rations may not meet vitamin-A requirements. If cattle enter the feed lot with a depleted reserve because of grazing for prolonged periods on dry range, this deficiency may occur unless roughage of bright green color is used. In 1934, a striking example of such deficiency was found in a herd of 560 head of yearling steers and heifers which were brought from dry range and placed on a ration of bleached hay and straw, cottonseed meal, raisin stems, and barley. After 25 days on this ration, gains were low, the cattle unthrifty, their hair rough, and eyes watering. Many showed defective vision in twilight, and some were definitely night-blind. The addition of 3 pounds of bright alfalfa hay or lima-bean straw remedied the condition. Gains became normal, and the cattle thrifty within 30 days. Another group of 350 head of older cattle brought to the feed lot earlier showed similar symptoms after 120 days on feed. They also responded to green roughage in the ration.

Age of Cattle.—After maintenance requirements are met, young cattle can use feed for both growth and fattening, while the mature animals' use of the ration above maintenance is confined to the production of fat. For this reason calves fed on complete rations possessing quality, variety, and balance, produce more economical gains than yearlings, which in turn make cheaper gains than two-year-olds. Since young cattle require more concentrates, less roughage, and higher quality feeds, the older cattle are better adapted for fattening when large amounts of coarse bulky roughages are to be utilized. Two- and three-year-old steers, for example, are often fattened on pasture or beet tops without concentrates, or may be fairly well finished in the feed lot on hay alone or such a ration as hay and silage. Strictly roughage rations will not fatten calves or yearling steers. If such rations are of good quality, yearling steers will make satisfactory gains on them, but mostly in the form of growth. Yearling heifers, if they are well-bred and have early maturing tendencies, sometimes fatten without the aid of concentrates if the roughage or pasture is of good quality and relatively high in digestibility.

Since two-year-old cattle need less of their feed for growth, the fatten-

ing period required is only about one half the time necessary to fatten calves. Sometimes conditions warrant limited feeding, and the time for each class is accordingly increased.

The younger the animals the greater attention is necessary to details of feeding. Calves are more susceptible to irregular feeding practices and to muddy feed lots. Fattening calves and yearlings seem less susceptible to extremely hot weather than two-year-olds.

Superior type, high quality, and desirable conformation of animal are essentials when fattening calves. Plain and rough animals do not finish readily as calves, although they may make good gains. Such animals had better be held for fattening at an older age.

The time for marketing calves and yearlings is more flexible than that for two-year-olds. If current market conditions are unfavorable when calves or yearlings are intended for market, they may be held for several additional weeks or even months and continue to make efficient gains. Two-year-olds have a much narrower time limit for producing economical gains.

Sex.—The average calf crop is about equally divided between steers and heifers. Over a period of years about one half of the heifers, theoretically the best ones, are retained for breeding-herd replacements. This means that about 25 per cent of the annual output from breeding herds is composed of heifers that compete directly with steers in the feeder- and slaughter-cattle market. Usually a substantial price spread exists between steer and heifer feeders and also between the two classes when the animals are ready for slaughter. In years when cattle numbers are expanding, there is a tendency to hold back more heifers for breeding purposes; supplies of all slaughter cattle are usually lighter, and the spread in price between steers and heifers is less than in periods of over-production when a greater percentage of heifers and cows are offered for market.

For years, prejudice has existed in the markets against heifers, based largely on the danger of their being pregnant and the claim that heifers produce more wasteful carcasses than steers. To overcome the objection to bred heifers and to permit running of market heifers with the general herd, some producers have followed the practice of spaying. The criticism of heifer carcasses being wasteful is somewhat reduced with the trend toward marketing more of them as yearlings and calves.

Numerous tests have been conducted at state experiment stations to determine the extent of justification for discriminating against feeder and slaughter heifers as compared with steers of the same age, grade,

and weight. Significant conclusions may be drawn from the results of these experiments and from field tests in California :

1. Heifers, both spayed and open, fatten faster than steers and therefore reach a given slaughter grade sooner than steers. The heifers usually make smaller gains than steers but when both classes are marketed with the same degree of finish and before they become excessively fat, the economy of gain is not greatly different.

Ranch records obtained by the Agricultural Extension Service on 1,149 yearling heifers compared with 587 steers of the same age and quality and fed on similar rations wherein each class was marketed at a weight and finish suitable for California markets show the following : The different lots of steers were fed from 75 to 135 days; the heifer lots from 72 to 118 days. The steers made an average daily net gain of 1.90 pounds, and heifers, 1.81 pounds. The heifers produced their gains on 16 per cent less feed than the steers.

Six experiments cited by Morrison¹⁰ showed that heifer calves fattened for 165 days compared with steer calves fed for 233 days gained the same, 2.24 pounds daily. The feed required for 100 pounds gain was slightly less for the heifers.

2. If slaughtered before excessively fat ("Good" or "Good to Choice" grades at 750 pounds or less in weight), yearling heifers and heifer calves yield comparably with steers, and show little, if any, more waste of carcass than steers. Under these conditions, cutting tests revealed no appreciable difference in percentage of desirable cuts. If fattened to the "Choice" or "Prime" grades, heifers are less desirable in the market, their carcasses are more wasteful, and their cost of fattening is unnecessarily increased.

3. Two-year-old heifers produce more internal fat and carcass waste than yearling heifers and calves, and compare less favorably with steers of the same age than do the younger heifers.

4. Tests at the Nebraska and California stations show that spaying neither increases the rate and economy of gain nor improves dressing percentage. Any advantage from spaying comes through the guarantee that heifers are not bred, or from convenience in allowing market heifers to graze with the general herd on the range.

5. In quality and palatability, heifer beef is equal to steer beef.

Thin cows and bulls if healthy and not too old will make heavy gains on good pasture or in the feed lot. They are not, however, nearly as efficient as young growing animals or mature steers in the production

¹⁰ Morrison, F. B. Feeds and feeding. 20th edition. The Morrison Publishing Company, Ithaca, N. Y. 1050 p. 1936.

of beef, and a wider margin is required between feeder and fat prices of such animals. Sometimes, especially during the fall months, thin range cows and bulls can be purchased at very low prices. Pacific Coast markets for slaughter cows and bulls are relatively strong and constant. Under such conditions, the feeder who knows his markets, is a good judge of these classes of cattle, and has plenty of cheap feeds, can often purchase feeder cows and bulls to advantage. Rarely if ever does it pay,



Fig. 22.—This type of steer will fatten readily as a calf, yearling, or two-year-old, will make economical gains, and will justify finishing to "Choice" grade.

however, to use heavy amounts of high-priced feeds for fattening cows or bulls. When plenty of good pasture is available, opportunity for profit from purchasing feeder cows is increased if the cows produce calves that will fatten as veal early enough in the season to permit the cows to fatten after the veal is sold. The purchase of cows for feeding on ranches that maintain breeding herds is not recommended because of the danger of introducing Bang's and other diseases.

Type and Market Grade.—Type relates particularly to conformation, natural fleshing, and quality—all determined by breeding. Market grade is determined by type, plus condition of the animals. The different kinds of steers and heifers are here grouped arbitrarily into four general types that reflect in general the standard market grades:

Type 1 includes the well-bred, low-set, thick-fleshed, deep- and wide-bodied animals having plenty of capacity, moderate-sized bone, short,

wide heads, quiet disposition, and heavy weight for age. Animals of this type, exemplified by figure 22, can be depended upon to gain rapidly, economically, and finish readily as calves, yearlings, or two-year-olds; and they are also the first to fatten on the range or other pasture. They meet a wide market demand when properly finished and are the most desirable kind to breed and raise because of their wide adaptability. As feeders, cattle of type 1 represent the "Fancy," "Choice," and "Good to Choice" grades. Only a very limited number of "Fancy" feeders are available, and when sorted into uniform lots, go to a specialty market at a premium in price. The demand for the "Choice" and "Good to Choice" feeders, especially in the yearling and calf ages, usually exceeds the supply. The slaughter grade for cattle of this type depends on their degree of finish. In a short fattening period, they readily reach the "Good" grade; with a moderate finish they will be "Good to Choice" or "Choice"; and if fed to a high degree of finish make the "Prime" grade of slaughter cattle. For California markets, the producer is usually justified in feeding such cattle until they attain the "Good to Choice" slaughter grade.

Type 2 refers to cattle that are similar to those of type 1 in general characteristics except that they are fine-boned and therefore do not have the ability to gain as heavily. They produce trim, tidy carcasses that are attractive to the packer, but these animals are less efficient under most conditions than type 1. Such cattle are best finished at a young age. The market grading for cattle in type 2 will correspond closely to that described for type 1.

Type 3 represents the big, coarse, rough, and heavy-boned animals having good feed capacity but lacking in quality. Such cattle usually make large gains but are slow-maturing and grow rather than finish when fed at a young age. They can often be used to advantage in marketing large amounts of cheap roughages. These animals are efficient users of moderate amounts of concentrates but if held for long periods on high-priced feeds are less desirable than type 1 because of greater limitations in improving their market grade and selling price. Carcasses are apt to be wasteful and unattractive. As feeders, cattle of type 3 are mostly in the "Good," "Medium to Good," and "Medium" grades. It rarely pays to feed them beyond the "Good" slaughter grade, although the better animals if fed for longer periods may make the "Choice" grade of slaughter cattle. The supply and demand for this type of cattle are usually fairly well balanced.

Type 4 includes the plain, leggy, shallow-bodied, flat-ribbed, light muscled, long-necked, narrow-headed kinds that often have nervous dis-

positions, lack feed capacity, and make light gains. As feeders, cattle of type 4 come in the "Common to Medium" and "Common" market grades. Animals representing the upper limits sometimes attain a fairly smooth covering and "Medium" slaughter grade in a relatively short time and should then be sold. Further finishing will seldom enable them to reach the upper grades of slaughter cattle. Most of the cattle of this type are "Common to Medium" when slaughtered. An experienced buyer and expert feeder who understands the limitations of such cattle can sometimes realize more profit from them than from the upper grades. For the breeder and grower, however, they nearly always represent a poor investment.

Length of Feeding Period.—If cattle are fed to a very high degree of finish, gains become much more expensive during the latter part of the feeding period. Gains at this stage consist more of fat and less of water, feed consumption per unit of animal weight is lessened, and a smaller proportion of the feed consumed can be used for building body tissues. It should be emphasized that a moderate amount of fat is necessary to give proper flavor to meat, but excessively fat animals are an economic loss to both producer and consumer. Less-fat animals make more efficient use of the producers' feed, and cuts of meat that are only moderately fat cause less waste to the consumer.

Feeding Practices.—Sorting of cattle, preparation and mixing of feeds, regularity of feeding, and contentment of animals, all affect the rate and economy of gains in both pasture and feed-lot feeding.

Sorting: Many cattle feeders pay dearly for the practice of feeding and selling cattle in a "mine-run" fashion. There is much to be gained through proper sorting, especially where large numbers are involved and where considerable variation exists in the weight, quality, condition, and class of animals. Where practicable, the sorting of light cattle from heavy cattle, horned animals from hornless, steers from heifers, better-quality from inferior, and the placing of the nervous, "high-headed" kind by themselves, are sure to bring beneficial results. Some cattle gain poorly, not because of type, breeding, or quality, but because of such conditions as disease, parasites, or injury. These "poor doers" should be segregated, fed separately, and sold at the earliest opportunity. The feeder, by sorting, can better adjust the kind and amount of feed to be used according to the appetite and efficiency of the cattle. Less trouble will be experienced with the animals' overeating, undereating, or "going off feed." One of the greatest advantages in sorting comes at market time. All lots need not be disturbed every time a sale is made. Well-sorted cattle are always more attractive to the buyer. Both the upper and lower

grades look better when segregated. Only to a very limited degree can the good cattle be expected to sell poor ones. Finally, if the feeder does not have his cattle sorted, the buyer will sort them for him and often to the disadvantage of the seller.

Mixing of feeds: The grinding and chopping of feeds are discussed in the second part, "Nutrient Requirements and Cattle Feeds." The desire to feed concentrates and roughages mixed together is one of the principal reasons why many feeders prefer chopped or ground hay. Other feeders choose to feed concentrates and roughages separately. Both methods have their advantages and limitations. Where the operator is dependent on hired help to feed large numbers of cattle, the feeding of all feeds mixed together is a somewhat safer procedure, with less danger of cattle receiving too much concentrates; and labor cost also is reduced. The advocates of feeding concentrates and roughages separately declare that by so doing they can more nearly judge the appetite of the cattle for concentrates as compared with roughages and can thus better regulate percentages in a ration. Furthermore, they can more conveniently adjust the percentages of each class of feed for different lots of cattle. The separation of concentrates and roughages also permits the feeding of the two classes of feeds at different times of the day. The careful and experienced feeder with small numbers of cattle can undoubtedly feed more accurately and with greater control when concentrates are fed separately from roughages.

Regularity of feeding: The diligence of the feeder and his watchful eye are of utmost importance in fattening cattle, especially when concentrated feeds are used in the ration. One serious mistake may cancel a week's gain.

Concentrates should be introduced into a ration slowly and cautiously, particularly when cattle have not been accustomed to them through previous supplemental feeding. Experienced operators observe that feeder cattle that have received concentrate supplements in their stocker stage start on feed more readily and are quieter and easier to handle. If cattle are brought to a strange feed lot and are entirely unaccustomed to concentrate feeds, it is advisable to feed them on roughage alone for two or three days before starting the concentrates. In separate feeding of concentrates, it is well to feed $\frac{1}{2}$ to $\frac{3}{4}$ pound at a feed to calves or light yearlings for the first four or five feeds. Older and heavier cattle may be started on $\frac{3}{4}$ to 1 pound of concentrates. These initial amounts can be a little greater if the cattle have previously been accustomed to concentrate feeds.

All increases in concentrated feeds should be made gradually and

only as the animals will clean up their feed readily without digestive disturbances. Trouble can often be avoided by making more frequent and smaller increases rather than fewer and greater advances. The amount of increase and the time required to bring the cattle to full feed must depend upon the judgment of the feeder. Few lots of cattle react exactly the same to a given ration.

If cattle go "off feed" as evidenced by refusing to clean up their ration or by digestive disturbances such as scouring or bloating, the ration should be reduced and more dry roughage and less concentrates used for a few days. If the difficulty involves only a few animals, they should be segregated from the others. If many animals go off feed or show digestive disturbances, something is radically wrong with the ration, method of feeding, or both.

At no time during the feeding period should any radical changes be made, either in the kind or amount of concentrates or roughages. Many lots of cattle suffer severe setbacks from such procedure. Changes in feed or too sudden increases are conducive to digestive disturbance and, in cattle having latent coccidiosis, may bring on acute symptoms. These are manifested by scouring, bloody mucus in the manure, and in severe cases, passing of fresh blood from the rectum. Segregating such animals to minimize spread of infection and feeding them exclusively on dry hay is a practical remedy. Fattening cattle require clean, fresh feed and should not be required to eat once-refused or dirty feed. Any such feed should be removed and used for stock cattle or other animals not being fattened for market.

When all concentrates and roughages are fed in a cut mixture, concentrates may compose a slightly greater percentage of the total feed at the start than where these two classes of feeds are fed separately. In feeding cut mixtures, however, it is always safer to employ a series of numerous different mixtures for bringing the cattle to full feed. The following schedule illustrates how rations of cut mixtures can be changed gradually in 10 stages from mixtures containing 10 per cent concentrates and 90 per cent roughage to final finishing rations of 55 per cent concentrates and 45 per cent roughage:

Concentrates (per cent of total mix)	10-15-20-25-30-35-40-45-50-55
Roughages (per cent of total mix)	90-85-80-75-70-65-60-55-50-45

Many experienced feeders do not use all these stages in advancing cattle to a heavy concentrate feed, but the numerous steps are advisable for greater safety against common occurrences of cattle going off feed.

Contentment of animals: Fattening cattle that are comfortable and

contented make better use of their feed and produce greater gains at less cost. The following suggestions in this connection are for the inexperienced cattle feeder :

1. Limit the number of cattle to be fed together to 75 and preferably to 50 or 60 head.
2. Provide at least 2 feet of space at the feed troughs for young cattle and about $2\frac{1}{2}$ to 3 feet for mature cattle.
3. Always handle cattle quietly and with as little commotion as possible.
4. In the feed lot, provide liberal bedding of straw when necessary to keep the animals comfortable. The straw will help to retain much of the fertilizer value of the liquid portion of the manure.

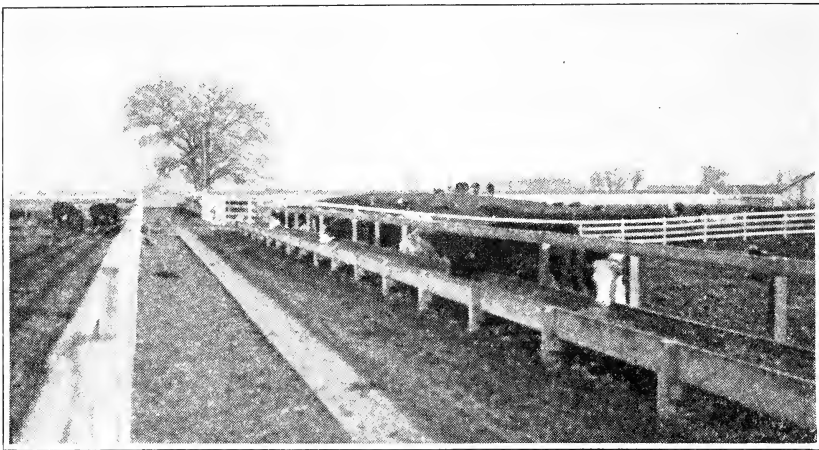


Fig. 23.—An economical type of feed-bunk construction for convenient feeding of silage, cut mixtures, wet beet pulp, or wet brewers' grains. In the right background is shown a mound built to reduce muddy feed-lot conditions.

5. In the absence of sheds, windbreaks are a decided protection against cold, driving rains. Shade promotes contentment in hot weather.

6. Mud is the bane of many an operator who feeds cattle in the rainy season and often presents a problem most difficult to solve. Mud is more detrimental when occurring in the latter, and more expensive, part of the fattening period than early in the period. Mud affects gains on calves and yearlings sooner than on older cattle. These points are significant for consideration in planning the season of feeding.

Fattening cattle will withstand a great amount of mud if they can find a reasonably dry or at least firm spot to lie down. When forced to wade through deep mud for prolonged periods with no good spot to rest, gains are sharply reduced and sometimes disappear. Mud-covered cattle may be discounted by the buyer to further increase loss.

In locating the feed lot every advantage should be taken of any sandy, gravelly soil or rocky knolls. On flat ground the building of mounds in the lots as shown in figure 23 helps to some extent. It is often practicable especially with small numbers of cattle, to have separate bed grounds adjoining the feeding corral. Such lots, when kept well bedded with straw, will be a welcome change to the cattle for a few hours

each day. On some farms, barns or sheds constructed for other purposes can be converted at little expense into feeding and bedding places for fattening cattle during inclement weather. The cattle feeder who finds it necessary or feasible to fatten cattle each year in wet feed yards may well investigate the advisability of paving a portion of his feed lots if other means of combatting the mud problem are not satisfactory.

The minimum space for fattening cattle is 100 to 125 square feet per animal. Twenty-five to 30 square feet which can be bedded under a shed in addition to 75 to 100 square feet of lot space per head is ample. An inexpensive shed bedded with straw and a paved lot may be a cheaper and more permanent solution of the mud problem than gravelling larger areas or building mounds. This is particularly true on heavy, poorly drained soils. This also has the definite advantage of protecting feed from rain and of conserving manure.

Production and conservation of manure: Studies cited by Morrison¹¹ indicate that manure production from fattening cattle including bedding is about $\frac{3}{4}$ ton per month. In California trials, extending over a 210-day period with fattening calves, about $\frac{1}{4}$ ton of bedding was used per animal. Including this bedding, about 3 tons of manure (as hauled) or 1.6 tons of air-dry manure was produced by each steer. This amounts to 460 pounds per month. For two-year-old cattle, about 700 pounds per month would be a fair estimate. On a wet basis, these figures agree well with Morrison's data. Since more than half the nitrogen excreted is in the urine, use of bedding is particularly important in conserving this valuable fertilizer constituent. When animals are bedded under a shed, it is usually unnecessary to clean out the manure during an ordinary feeding period if the animals are kept supplied with a liberal bedding of fresh straw. Manure leached by rain loses much of its fertilizer value. Some convenient feed-lot equipment is shown in figure 24.

FATTENING CATTLE ON PASTURE

Maximum use of grazing in the fattening of cattle has several advantages over total dependence on feed-lot finishing. On good pasture and with proper management, gains are cheaper than in the feed lot. Roughages obtained through grazing cost less than when secured from harvested feeds. If concentrates are used, a more limited amount is ordinarily fed and less of the more expensive protein supplements are usually required on first-class pastures. Labor and equipment costs for pasture fattening are less than in feed-lot feeding.

At the lower elevations in California possibilities for extended use of pastures in fattening cattle are greater than in most other regions of the country. When the unirrigated ranges and pasture lands have passed

¹¹ Morrison, F. B. Feeds and feeding. 20th edition. The Morrison Publishing Company, Ithaca, N. Y. 1050 p. 1936.

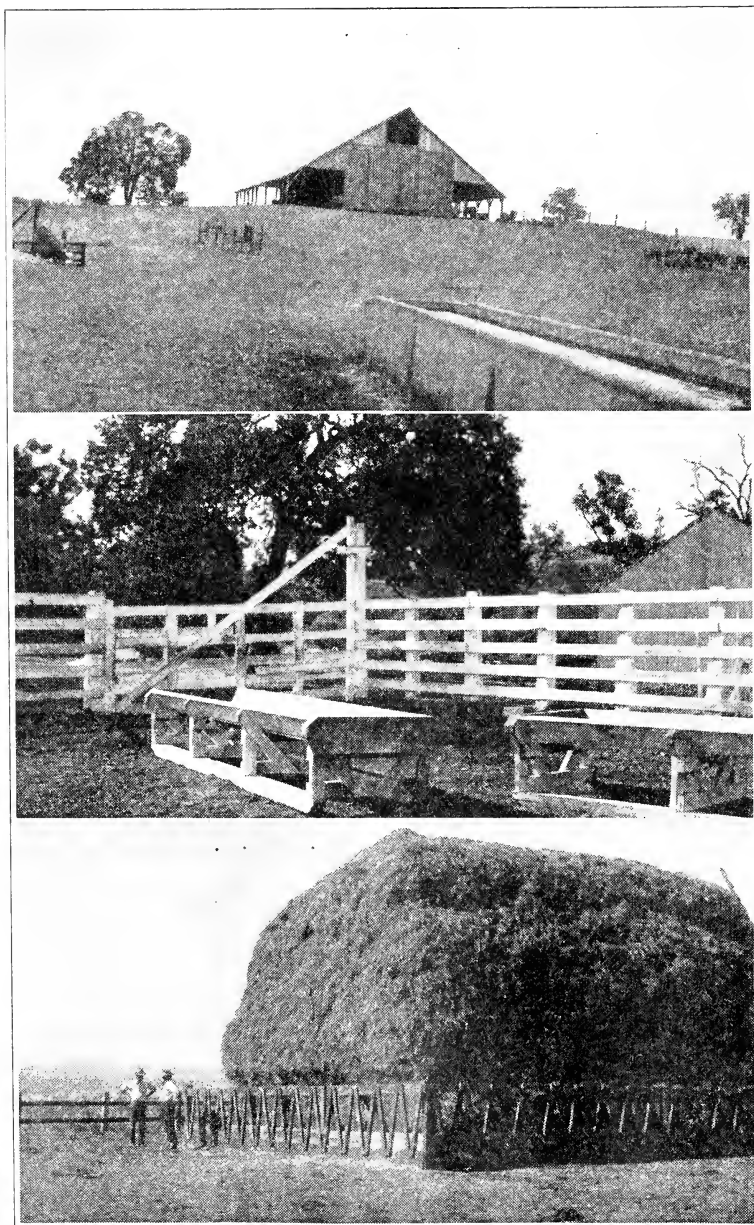


Fig. 24.—The feeding shed (upper) is located to permit good drainage. It provides feed storage space, shelter for animals in wet weather, and shade in hot weather. The movable grain bunk (center) is sturdy and convenient for use where concentrates and roughages are fed separately. The stanchion-type hay rack (lower) is built in sections and can be readily moved. This type of rack reduces waste of hay to a minimum.

their peak season, the irrigated pastures and aftermath of cultivated crop lands furnish extensive grazing in the farming districts.

Pasture fattening may refer to grazing with no concentrate supplement, or to the feeding of concentrates for a part of the period, or feeding for the entire grazing period. In this state the pasture fattening of cattle commonly involves grazing on ordinary range pastures or meadows, grazing of irrigated pasture mixtures or alfalfa, grazing on the aftermath of grain and hay lands, or the grazing of beet tops.

The degree to which cattle will fatten on pasture without any supplemental feeds depends not only on abundance of palatable forage but on the stage of its growth or maturity and also the condition, age, and quality of the animals. The seasonal changes in nutritive value of pasture forage are discussed in the second part of this circular. Unless cattle are nearly ready for market when the pastures dry, they fail to fatten without the aid of additional feeds. The chances of fattening dry cows, three-year-old steers, and two-year-old dry heifers on pasture without extra feed are better than for two-year-old steers. If the latter are the slow-maturing kind or have been allowed to lose materially in weight as calves or yearlings, their chances of fattening on pasture alone are not very good, although they may make a gain equal to that of the older cattle. On the other hand, two-year-olds which possess early-maturing tendencies and have been allowed to gain continuously since calthood, may reach "Medium to Good" or sometimes "Strictly Good" slaughter grade on pasture without supplements.

Numerous situations justify the feeding of concentrates in connection with pasture to assure or hasten the fattening of cattle. Very often, especially with older cattle, such feeding produces satisfactory slaughter condition on animals that would otherwise require a more expensive feed-lot finishing period. With yearlings the feed-lot period can be greatly reduced and sometimes eliminated if good pasture is supplemented by concentrates. The practical problem that confronts the stockman is when to feed supplements and which concentrates will give the best results. The following suggestions will serve as a general guide for feeding supplements on pasture:

1. Successful fattening of cattle on native range should be based more on the use of concentrates while the pasturage is still nutritious and palatable rather than by delaying supplemental feeding until the forage is of low value and unpalatable. For maximum gains and best returns from concentrates fed on any type of pasture, forage must possess quality and be abundant. When the pasture reaches a stage when animals cannot readily obtain a full feed of good-quality roughage they should be moved to fresh pasture or into the feed-lot for finishing.

2. If concentrates are added when green pasture forage is in an early stage, gains can be materially increased. At this stage cattle will usually consume 1 to 1½ pounds of concentrates for each 100 pounds live weight.

3. As a forage advances toward the mature stage, it more nearly meets requirements of the animals, and concentrate consumption is usually reduced. The amount of reduction depends largely on the comparative kind and quality of the pasturage and concentrates as well as on the abundance of pasture and on feeding conditions. Sometimes feeders desire that animals continue on maximum concentrate rations during the good grass period in order to hasten fattening. This can be more nearly accomplished if the animals are in relatively small fields, go to water at a central point, if a variety of good concentrate supplements are used, and if the cattle are fed twice daily.

4. When the pasturage passes its peak season the cattle again take to the concentrates more readily and consume from 1 to 1½ pounds per 100 pounds live weight.

5. Green pastures contain a sufficient amount of protein for fattening animals. Carbohydrate concentrates, such as grains, dried fruit by-products, beet pulp, or molasses, are therefore better adapted for supplementing green pasture than the protein concentrates like cottonseed cake. Furthermore, the carbohydrate feeds are usually cheaper.

6. Where clover, alfalfa, or other legumes constitute an important part of green pastures, bloat is usually a problem and often a very serious one. No certain way of avoiding bloat on such pastures has been discovered. There is strong evidence that free access to dry hay, preferably nonlegume, or to straw, materially reduces the danger of bloat. Bloat troubles are also probably lessened when the concentrate ration contains a good variety of feeds. If alfalfa is grown to hay stage before pasturing there is less danger of bloat, the yield of forage is increased, and the stand is better maintained. Heavy bloat losses often occur where cattle graze on irrigated pastures comprised largely of Ladino clover. While Ladino and the other clovers provide abundant pasturage, it is strongly recommended that a good mixture of nonlegume pasture plants always be included with the clovers in seeded pastures intended for cattle grazing. In the best cattle pastures, legumes do not exceed 50 per cent of the total forage. The variety of pasture afforded by mixtures will not only reduce bloat danger but improve utility of the pasture.

Pastures kept moist by frequent irrigation are liable to become heavily infested with internal parasites, particularly stomach worms. This factor must be considered in pasture-fattening operations.

7. Dry pasture usually does not supply sufficient protein for fattening cattle, and the addition of a protein concentrate will improve the supplemental ration. Cottonseed cake or meal (40–43 per cent protein) or their equivalent, constituting about 15 to 20 per cent of the total concentrates to be fed, will provide the needed additional protein. Should protein concentrates be no higher in price than the carbohydrate feeds, greater amounts may be economically fed. Results of pasture feeding are presented in table 11. These will aid the feeder in figuring the cost of pasture feeding and necessary margin. A detailed discussion of factors influencing necessary margin is given in the concluding section.

Beet-Top Pastures.—The characteristics and analyses of sugar-beet tops are discussed in the second part of this circular. Under present conditions in California where most tops are pastured while scattered in

TABLE 11
RESULTS OF SUPPLEMENTING PASTURE IN CALIFORNIA EXPERIMENT STATION AND RANCH TRIALS*

Cattle	Number of cattle	Average daily ration, pounds	Average initial weight, pounds	Length of period, days	Average daily gain, pounds	Pounds feed for 100 pounds gain
Two-year-old steers	24	{ Dry grass-flaree range. Barley..... 3 0 Cottonseed cake..... 2 0 }	650	169	1 24	Concentrates..... 403
Two-year-old steers	97	{ Dry grass-flaree range. Barley..... 3 3 Beet pulp..... 2 2 Cold-pressed cottonseed cake..... 4 3 Grain hay..... 3 2 }	808	75	1 54	{ Concentrates..... 633 Hay..... 209 }
Long yearling steers	11	{ Dry grass range. Barley..... 5 2 Cottonseed cake..... 2 6 }	772	70	1 53	Concentrates..... 511
Two-year-old steers	14	{ Dry grass range. Barley..... 5 5 Cottonseed cake..... 2 7 }	1,089	49	1 06	Concentrates..... 775
Two-year-old heifers	444	{ Dry grass-flaree range. Barley..... 4 1 Dried beet pulp..... 2 3 Cold-pressed cottonseed cake..... 2 7 }	733	60	1 32	Concentrates..... 684
Yearling steers	48	{ Partially irrigated meadow† Barley..... 3 9 Raisins..... 3 3 Cottonseed cake..... 1 1 Alfalfa..... 5 1 }	495	130	1 61	{ Concentrates..... 514 Hay..... 319 }

TABLE 11—Continued

Yearling heifers.....	250	{ Dry grass-flaree range..... } { Barley..... } { Dried beet pulp..... } { Cottonseed cake (43 per cent protein)..... }	552	87	1.69	Concentrates..... 523
Yearling heifers.....	79	{ Partially irrigated meadow..... } { Barley..... } { Raisins..... } { Cottonseed cake..... } { Alfalfa..... }	430	113	1.51	{ Concentrates..... 505 } { Hay..... 227 }
Steer calves.....	24	Alfalfa pasture alone.....	439	89	1.39	.....
Steer calves.....	24	{ Alfalfa pasture..... } { Barley..... }	584	105	1.95	Concentrates..... 429
Yearling steers.....	36	Alfalfa pasture alone.....	615	89	1.41	.....
Yearling steers.....	36	{ Alfalfa pasture..... } { Barley..... }	743	105	2.02	Concentrates..... 412
Yearling steers.....	254	{ Alfalfa pasture..... } { Barley..... } { Alfalfa hay..... }	673	124	1.50	{ Concentrates..... 358 } { Hay..... 672 }

* The different lots of cattle varied in type, quality, and market grades as feeders. Final slaughter grades were "Medium to Good" and "Good."

† Pasture dry the last 30 days.

the field, some of this valuable feed resource is lost because of trampling, drying, shattering, and blowing. The loss can be reduced through wind-rowing and piling of tops. Many growers and stockmen, however, feel that the expense of present methods for such conservation offsets the benefits obtained.

As previously pointed out, fresh tops contain a significant amount of oxalic acid, which makes it desirable to delay pasturing until about a week after harvesting the beets. The crowns of beets contain salts which have a laxative effect on the animals. It is advisable to supply good, dry alfalfa hay to cattle pasturing on beet tops. The hay is relished by the cattle. It tends to offset the laxative effect of the tops and to increase gain and hasten fattening. To obtain best results from beet-top pasture, cattle should not be allowed to roam at will over a large field. By use of temporary cross-fences they can be required to graze smaller areas at a time and can be moved frequently to fresh feed. Cattle well along in the fattening stage should not be compelled to graze the fields too closely. After the best of the tops have been salvaged, it is desirable that a follow-up herd of stock cattle or animals early in the fattening stage be used to clean up the remaining feed.

The value of fattening feed to be obtained from an acre of tops varies greatly according to the yield of beets, conservation of tops, amount of beet crown left with the tops, and feeding practices. The usual pasturing period is about 90 days. The tops from 1½ acres of beets yielding 15 to 20 tons per acre will furnish feed for one animal for about 90 days. It is advisable to move fattening cattle to fresh feed about every 2 weeks. This system requires more fences and water provision, but better results are obtained. Furthermore, preparation of the land for the next year is not delayed.

The following information was obtained from a summary of results with 781 head of two-year-old steers pastured on tops on two Yolo County ranches. The steers were fed an average of 82 days and made an average daily gain of 1.43 pounds. The average yield of beets was 16.6 tons per acre and about 1.1 acres of tops were required to produce 100 pounds gain. No hay or other supplements were fed. In the following year on one of these ranches the beet yield was about 12 tons per acre, and feeding conditions were less favorable. The average period for 451 steers was 94 days, and they made an average daily gain of 1.06 pounds.

The beet crowns that are left with the tops are high in carbohydrate and low in protein content, which helps to balance the low carbohydrate content of the stems and leaves. Most California beets are topped when the weather is very dry, and the crowns become rather hard. Sometimes

when eaten, a crown or small beet lodges in the animal's throat and causes choking. The lodged crown or beet can usually be removed, or pushed on down the esophagus with a heavy rubber hose. Experienced feeders find it advisable to keep a man on hand who can rope the distressed cattle or place them in a chute and give the customary relief. The choking may cause death in a short time unless assistance is rendered.

Mature cattle will fatten on beet tops alone or with alfalfa hay. Yearling steers and calves make satisfactory gains on tops but tend to grow rather than fatten unless concentrate supplements are fed. Many yearling heifers are fattened without the aid of concentrates. The grains and other carbohydrate concentrates that are not laxative in nature are desirable for supplementing beet-top pasture, with or without alfalfa hay. An ideal situation for pasturing beet tops is where the cattle can graze back and forth from tops, grain stubble, other dry cropland pasture, or alfalfa pasture. Such practice is more easily arranged on ranches where definite crop rotations are in operation and fields are relatively small.

FEED-LOT RATIONS

Both farmers and commercial feeders in California have several alternatives when planning rations for feed-lot fattening of cattle. The farmer who uses cattle primarily to sell his ranch feeds can often plan his crop program to produce feeds that will combine in a satisfactory fattening ration without the aid of any purchased supplements.

The total tonnage of digestible nutrients from alfalfa and grain hay, and threshed grains that is available to be marketed through cattle in California exceeds that of all other harvested feeds and by-products combined. These feeds, therefore, form the basis for most feed-lot rations. Important points to be considered in using hay and grain rations are :

1. A combination of two or more grains is always preferable to a single grain. Milo alone is better than barley alone. Wheat should never be fed as the only grain.
2. A ration composed solely of a full feed of barley and alfalfa hay can meet nutritive requirements, but such a combination sometimes produces serious bloat troubles. On long feeding periods, some cattle will tire of a straight barley and alfalfa ration with the result that feed consumption and gains are limited and uniform fattening of the lot is impaired.
3. The mixing of alfalfa and grain hay in equal parts will largely overcome bloat troubles. If this is done, a protein concentrate should be added to offset the deficiency in the grain hay. A mixture of grains will also tend to alleviate bloat.

Grain and hay rations can often be made more efficient and economical by the addition of palatable feeds other than protein concentrates. Recommendations for the use of several other feeds in replacing a portion of the grain or hay, particularly in feed-lot fattening are now presented.

Silage.—The advisability of producing silage for use in cattle-fattening depends on the character and prices of the feeds to be replaced, the yield and cost of the silage per acre, and the probable returns from other crops that might be grown on land devoted to silage crops.

Numerous tests have shown that the addition of silage usually will improve grain-and-hay rations, particularly those lacking variety. When silage is added to a barley and alfalfa ration, bloat troubles rarely occur. Rations that already possess quality, variety, and balance may be made more economical by using good-quality silage to replace more expensive feeds. When cattle are given a full feed of concentrates, corn silage, and alfalfa hay, the feed-replacement value of the silage per ton may be more than half that of the hay as shown by the following examples: An average of five trials at the Idaho Agricultural Experiment Station gives the results of adding corn silage to long alfalfa hay and barley for fattening steers weighing 896 pounds at the start and fed an average of 137 days. The alfalfa-barley lots ate 25.5 pounds hay and 8.89 pounds barley per head daily. Their average daily gain was 1.72 pounds, shrinkage to market was 3.6 per cent, and carcass yield, 60.2 per cent. The silage-fed lots consumed daily 19.3 pounds hay, 18.5 pounds silage, and 8.76 pounds barley, and made an average daily gain of 1.90 pounds. The shrinkage to market of the silage lots was 4.2 per cent, and the carcass yield 60.6 per cent. In these five trials each ton of silage replaced 964 pounds long alfalfa hay and 115 pounds ground barley. One California stockman, coöperating with the Agricultural Extension Service, conducted a 106-day trial wherein 170 head of two-year-old steers were fed daily per head an average of 13.7 pounds corn silage, 14.6 pounds mixed alfalfa and grain hay, and 9.3 pounds of a mixture of barley, molasses, and cottonseed meal. An equal number of steers comparable in grade and weight received 17.3 pounds of the hay and 11.3 pounds of the concentrates per head daily, but no silage. In this trial one ton of silage replaced 217 pounds barley, 221 pounds molasses, 72 pounds cottonseed meal, 345 pounds alfalfa, and 231 pounds grain hay. The average yield and carcass grade of the two lots were about the same.

Good-quality corn silage added to a ration consisting of legume hay alone will increase the rate of gain and may show a value per ton equal to the hay. In rations composed of grain, hay, and silage, the silage is fed at the rate of 1.5 to 3 pounds per 100 pounds live weight.

In California, corn and sorghums for silage are ordinarily produced under irrigation. Yields from 15 to 20 tons are not uncommon on good land. The value of the trench silo as an inexpensive and satisfactory means of storing silage has been fully demonstrated (fig. 25). Cost-of-

production studies show that corn silage represents fully as high a use of land as alfalfa when it can be fed near where it is produced.

The value of corn silage varies considerably with the amount of grain it includes. Grain yield depends somewhat on the strain of corn or sorghum used. Significant amounts of grain from sorghum silage pass through cattle undigested. The possibility of reducing this loss is suggested by experiments at the Kansas Agricultural Experiment Station.

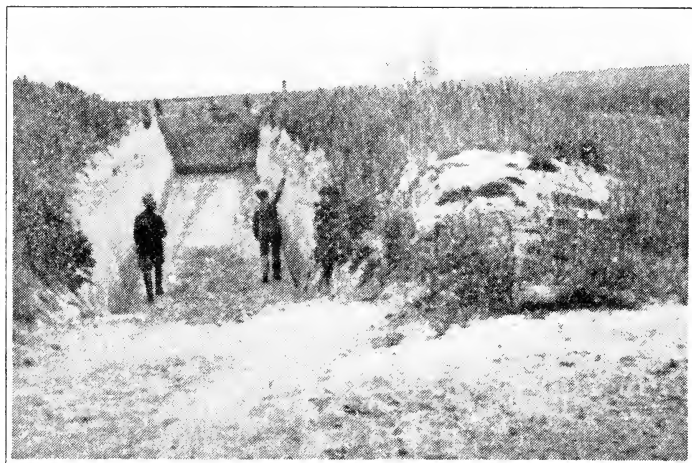


Fig. 25.—In this trench silo, corn yielding 60 bushels of grain and 18 tons silage per acre was stored with practically no loss from spoilage. When the silage was fed to yearling steers in a daily ration at the rate of 14.7 pounds per head along with 5.3 pounds grain and 8.7 pounds alfalfa hay, the cattle made a net daily gain of 2.33 pounds per head.

A combination knife-and-hammer mill was used with a regular silage cutter. Atlas sorghum was topped at the silo, the heads finely ground in the combination mill and dropped on the feed table of the ensilage cutter. The combined ground heads and cut forage were blown into the silo. A feeding test showed 12 per cent more gain from a ton of this silage than from the same feed run through the ensilage cutter only.

Wet Beet Pulp.—Most of the wet beet pulp in California has been utilized by a few commercial feeders who have feed yards located near sugar factories and who are prepared to handle large tonnages of pulp with little transportation. Recently this product has been more widely distributed among farmer feeders in the beet-growing districts located relatively near the sugar factories.

Wet beet pulp is bulky in nature and palatable to cattle. The dry matter is composed mainly of carbohydrates, and the fiber is highly digesti-

ble. Wet pulp is, however, deficient in both protein and phosphorus. When priced right, beet pulp can often improve the efficiency and economy of grain-and-hay rations, if provision is made to offset protein and phosphorus deficiency. When the feed lot is located near the source of supply, wet pulp in its various forms, fresh, siloed, or pressed, may be a cheap source of feed. Because of its high moisture content, it cannot economically be transported far. The wide variation in moisture content greatly affects its value per ton. Fresh pulp, which may contain as little as 5 per cent dry matter, is obviously worth far less than siloed or pressed pulp having 13 to 15 per cent dry matter. Cattle usually prefer well-fermented siloed pulp to the fresh product. When in the silo, loss from shrinkage may be 20 to 40 per cent. The loss is not only in water draining away but in nutrients lost in the fermentation process. Shrinkage loss can be reduced and the siloed product made better by keeping the exposed surface to a minimum. A greater exposed surface causes more drying and rotting. All of these factors must be considered in determining the value per ton of wet pulp. Cattle take readily to wet pulp. When fully accustomed to it and given all they will eat, and where little or no concentrates are used in the ration, the consumption may be as high as 8 to 10 pounds per 100 pounds animal weight.

In an average of four feeding trials at the Colorado Agricultural Experiment Station, siloed wet pulp added to a ration of barley, cottonseed cake, and alfalfa hay for fattening calves increased the gain, the selling price, the dressing percentage, and the carcass grade of the animals. Each ton of wet beet pulp replaced 142 pounds barley, 2.7 pounds cottonseed cake, and 342 pounds alfalfa hay. Tests at the Utah Agricultural Experiment Station have well demonstrated the possibilities of overcoming the phosphorus deficiency in beet pulp by the addition of a small amount of steamed bone meal. In these tests feeding of 0.1 pound per head daily of steamed bone meal to cattle receiving a ration of wet beet pulp, molasses, and alfalfa hay increased feed consumption, doubled the rate of gain, and materially reduced the cost of gain. Under these conditions the alfalfa hay supplied adequate protein.

Siloed pulp, fresh-pressed pulp, and dried molasses beet pulp were compared in two ranch feed-lot trials near Woodland. When both trials were averaged, there was no significant difference in rate of gain between the lots receiving dried and siloed pulp. The latter lots, however, required less dry matter to produce 100 pounds of gain. Tests at the Colorado Station showed dried pulp to have about 90 per cent the value of equivalent dry matter in siloed pulp—a value in substantial agreement with the Woodland trials. In both trials the rate of gain was slightly less

on fresh-pressed pulp than on siloed pulp, and there was an indication that the dry matter of the latter was somewhat more efficiently utilized.

Dried Molasses Beet Pulp.—Where used to replace not more than one half of the grains in a grain-and-hay ration or in feeding concentrates on pasture, dried molasses beet pulp has a feeding value about equal to barley. The amount of protein in the product will vary according to the percentage of molasses, especially when cane molasses is used. When cane molasses constitutes 25 to 30 per cent or more of the feed, the product will be low in protein, and provision should be made to offset this deficiency.

Raisins.—In years of surplus raisin crops, large quantities are devoted to livestock feed and may be fed satisfactorily in cattle fattening when used to replace not more than 40 per cent of the grain. In one ranch feeding trial in Tulare County, raisins and dried molasses beet pulp were compared in fattening rations for two lots of 50 yearling steers each. The feeding period was 111 days. Good-quality muscat raisins including very few stems were used at the rate of 2.6 pounds daily to replace an equal amount of pulp. In addition each lot of steers ate 3.4 pounds barley and 17.5 pounds of alfalfa hay per head daily. The rate of gain and feed required to produce gain was slightly in favor of the raisin-fed lot but the difference in this respect was not significant. When effort was made to increase the raisins beyond 40 per cent of the total concentrates, some were left in the trough. Experiences of other ranch feeders showed similar results.

Raisins available for livestock feed are apt to vary more in quality than a product like dried beet pulp. In years of fair price for raisins very little if any of the better grades go for livestock feed. Some lots of raisins contain a great amount of stems to decrease their feeding value. Wire and nails are sometimes present with raisins offered for livestock feed and may cause serious trouble when swallowed by the animals.

Dried Orange Pulp.—This product has total digestible nutrients equivalent to barley and is fairly palatable. Feeding experiences in California indicate that it should be fed in limited amounts to obtain its greatest value. Dried orange pulp and other citrus pulps were used to replace 25 to 45 per cent of corn in fattening rations at the Texas station. When fed in these amounts they produced results equal to corn.

Cane and Beet Molasses.—According to total digestible nutrients, cane and beet molasses are about equal, and have three fourths the feeding value of barley (table 9). The greatest returns from molasses in cattle-fattening rations are obtained when it is added to rations lacking in palatability. When used in small quantities, molasses may show a feed

replacement value equal to barley. In excess of 25 per cent of the grain ration, the value falls to three fourths that of barley. Molasses is commonly used in cut mixtures, on wet beet pulp, and often is sprinkled or sprayed over long hay. When molasses is low enough in price, self-feeding is found to be a satisfactory and economical way of handling it. Rarely will any difficulty be experienced from animals eating too much molasses where it is self-fed if they have access to plenty of dry feed of good quality. Further discussion of the characteristics of molasses and recommendations for mixing it with other feeds are given in the second part of the circular.

Roots and Tubers.—Cull potatoes, sugar beets, carrots, and other roots and tubers can often be used efficiently with other feeds in cattle fattening. Since they are high in moisture content, such products cannot be economically transported far. Best results are obtained from these feeds when fed in limited quantities to add succulence and palatability to grain-and-hay rations.

In one Idaho Agricultural Experiment Station trial, potatoes and corn silage were compared as supplements to alfalfa and barley for fattening steers. The steers were fed for 159 days and their average weight for the period was about 1,030 pounds. The potatoes were fed at the rate of 16.9 pounds daily, or about 1.5 pounds per 100 pounds weight of the steers. In this trial the potatoes had a feed-replacement value about equal to corn silage. In two trials of the Colorado Station potatoes and corn silage were compared in fattening rations for calves in which the other feeds were barley, cottonseed meal, and alfalfa hay. The calves were fed 194 days and averaged, for the period, about 610 pounds in weight. The potatoes were fed at the rate of 16.4 pounds, or about 2.7 pounds for each 100 pounds weight of the calves. In the Colorado trials the potatoes, fed in relatively heavy amounts, were worth much less than corn silage.

Potatoes can be successfully ensiled, but better results are obtained when they are mixed with some dry feed. In the Colorado trials, a silage composed of 82 per cent cull potatoes and 18 per cent corn fodder was about equal to corn silage in the fattening ration of calves.

Information on conservation and utilization of root crops is presented in the second part of this circular.

Brewers' and Distillers' Grains.—Wet brewers' grains and distillers' grains contain 75 to 80 per cent moisture and distillery slop from 93 to 96 per cent moisture. These products should be fed fresh to avoid danger of spoilage. Their economic use is therefore confined to feed-lot operations located near the brewery or distillery. Ordinarily these feeds are used in the fattening of the lower grades of mature cattle, and maximum

amounts are fed. A 1,000-pound animal may consume 40 to 50 pounds of wet brewers' grains containing approximately 10 to 12 pounds dry matter; up to 200 pounds of distillery slop, containing about the same amount of dry matter, may be consumed. The additional dry-matter requirements should be met through the feeding of dry roughage and some grain or other carbonaceous concentrate. The dry supplemental feeds used with these wet grains should be of a palatable nature. If alfalfa hay is fed for roughage, no protein concentrate is necessary in the ration, as the dry matter of the wet grains is about 25 per cent protein. Plain cattle being fattened on these wet grains ordinarily receive but a limited amount of concentrates. If good-quality cattle or young animals are to be fattened, the feeder is usually justified in allowing concentrates to constitute up to 50 per cent of the dry supplement.

Dried brewers' and distillers' grains are of only fair palatability. Their feed-replacement value is greatest when used in combination with other concentrates that are highly palatable.

Rough Rice.—Ground rough rice is palatable to cattle and satisfactory to use in combination with grain and hay rations. In a trial at the Missouri Agricultural Experiment Station it was fed to yearling steers at the rate of 13.1 pounds daily to replace a like amount of shelled corn. Other feeds in the ration were cottonseed meal and soybean hay. The rice proved to be highly palatable, and in this trial where it was fed as the only grain it was worth 76 per cent as much as shelled corn.

Straw.—When hay is high in price and straw cheap and abundant, the latter may be used efficiently in fattening rations if fed in limited amounts. The feeding value of each kind of straw differs widely according to the stage of maturity when cut, how the straw is preserved, and the amount of grain or seed included.

In general, grain straws are worth about half as much as alfalfa hay. They are low in productive value, protein, and palatability, and are high in fiber content. In feeding value, the common California grain straws usually rank as follows: oat, barley, and wheat.

Ordinary field-bean straw is coarse and fibrous and has a feeding value not greatly different from that of grain straw unless it contains a significant amount of beans.

Lima-bean straw is the best kind ordinarily available in California. It is usually leafy and palatable and has a feeding value about equal to good grain hay when fed in combination with other good-quality roughage.

Small amounts of pea straw and alfalfa straw are available for livestock feeding. These are usually intermediate in value between lima-bean and grain straw.

TABLE 12
RESULTS WITH FEED-LOT RATIONS IN CALIFORNIA EXPERIMENT STATION AND RANCH TRIALS*

Cattle	Number of cattle	Average daily ration, pounds	Average initial weight, pounds	Length of period, days	Average daily gain, pounds	Pounds feed for 100 pounds gain
Steer calves.....	12	{ Alfalfa..... 7.3 } { Barley..... 9.6 }	413	210	2.11	{ Concentrates..... 454 } { Hay..... 346 }
Steer calves.....	12	{ Alfalfa..... 6.9 } { Barley..... 9.1 } { Cottonseed meal..... 1.0 }	414	210	2.15	{ Concentrates..... 466 } { Hay..... 318 }
Steer calves.....	12	{ Corn silage..... 11.9 } { Alfalfa..... 3.0 } { Rolled barley..... 8.7 } { Cottonseed meal..... 1.0 }	417	210	2.18	{ Concentrates..... 445 } { Silage..... 543 } { Hay..... 137 }
Yearling steers.....	10	{ Alfalfa..... 8.9 } { Barley..... 10.4 }	605	114	2.15	{ Concentrates..... 481 } { Hay..... 413 }
Yearling steers.....	10	{ Alfalfa..... 13.2 } { Barley..... 6.8 }	591	121	1.91	{ Concentrates..... 354 } { Hay..... 691 }
Yearling steers.....	10	{ Cottonseed hulls..... 18.8 } { Cottonseed meal..... 7.7 }	612	112	2.11	{ Concentrates..... 362 } { Hulls..... 891 }
Yearling steers.....	10	{ Alfalfa..... 10.9 } { Barley..... 8.3 }	557	150	1.99	{ Concentrates..... 419 } { Hay..... 550 }
Yearling steers.....	10	{ Wild oat hay..... 9.9 } { Barley..... 7.0 } { Cottonseed meal..... 1.8 }	557	150	2.03	{ Concentrates..... 434 } { Hay..... 485 }
Yearling steers.....	10	{ Wild oat hay..... 11.6 } { Barley..... 4.0 } { Cottonseed meal..... 2.0 } { Molasses..... 2.9 }	557	150	1.92	{ Concentrates..... 462 } { Hay..... 605 }
Yearling steers.....	15	{ Alfalfa..... 8.2 } { Barley..... 5.2 } { Dried molasses beet pulp..... 6.3 } { Cottonseed meal..... 0.3 }	649	158	1.85	{ Concentrates..... 636 } { Hay..... 442 }

TABLE 12—Continued

Yearling steers.....	14	{ Alfalfa..... 8.1 } { Barley..... 5.3 } { Molasses..... 1.8 } { Siloed beet pulp..... 39.0 } { Cottonseed meal..... 0.24 }	646	147	2 08	{ Concentrates..... 348 } { Beet pulp..... 1,869 } { Hay..... 388 }
Yearling steers.....	50	{ Alfalfa..... 17.4 } { Barley..... 3.4 } { Dried beet pulp..... 2.6 }	566	111	2 22	{ Concentrates..... 270 } { Hay..... 781 }
Yearling steers.....	50	{ Alfalfa..... 17.6 } { Barley..... 3.4 } { Raisins..... 2.6 }	562	111	2 31	{ Concentrates..... 258 } { Hay..... 761 }
Short-yearling steers.....	42	{ Alfalfa..... 8.7 } { Corn silage..... 14.7 } { Corn and cob meal..... 5.3 }	462	134	2 33	{ Concentrates..... 227 } { Silage..... 373 } { Hay..... 633 }
Yearling heifers.....	12	{ Alfalfa plus 20 per cent molasses..... 10.3 } { Concentrate mixture..... } { Barley 50 per cent..... } { Dried beet pulp 40 per cent..... 8.6 } { Cottonseed meal 10 per cent..... }	573	118	1 85	{ Concentrate mixture..... 467 } { Alfalfa-molasses meal..... 556 }
Yearling heifers.....	305	{ Ground mixed hay..... 13.7 } { Corn silage..... 9.0 } { Barley..... 4.8 } { Molasses..... 2.6 } { Cottonseed meal..... 1.6 }	578	72	2 06	{ Concentrates..... 435 } { Silage..... 435 } { Hay..... 661 }
Two-year-old steers, "tail enders"†.....	170	{ Ground alfalfa..... 10.2 } { Ground grain hay..... 7.1 } { Barley..... 5.9 } { Molasses..... 3.4 } { Cottonseed meal..... 2.0 }	791	106	1 49	{ Concentrates..... 702 } { Roughage..... 1,167 }

* The different lots of cattle varied in type, quality, and market grade as feeders. Most lots attained "Good" or "Good to Choice" slaughter grades and yielded from 57 to 60 per cent. Very little feed was wasted or unaccounted for.

† Vitamin-A deficiency occurred at the end of 112 days and was cured by alfalfa feeding.

‡ Cattle left after several times "topping" of the better-gaining cattle.

For best results in fattening, straw from grains and field beans should be limited to 25 to 30 per cent of the total roughage. Lima-bean straw can satisfactorily constitute one half of the total roughage.

The results of numerous California feeding tests and of ranch feeding records are presented in table 12. These may be used in computing fattening costs with comparable cattle and rations and in figuring necessary margin as discussed in the concluding section.

CREEP-FEEDING OF CALVES

Under certain conditions in California the practice of creep-feeding calves continues to grow in use and popularity. In creep-feeding, young calves are allowed access to extra feed while they are still nursing their dams. The feed is placed in a self-feeder, trough, or rack and within a small enclosure. In the fence are openings through which the calves may go, or "creep," but which are too small to permit the cows to enter. Calves which are to be fattened and slaughtered at an early age are often creep-fed to induce faster finish and shorten the feeding period after weaning. Well-bred creep-fed calves when properly fed attain a weight of 700 to 800 pounds and a desirable market finish at 10 to 12 months of age. The creep-fed calves may not make as great gains in the feed lot after weaning as calves which receive no grain during their nursing period. When calves are creep-fed from a few weeks in age, however, the total feed required to fatten them is usually less than where calves are not fed until after weaning. Creep-feeding of calves during the nursing period produces more uniform calves. Calves from heifers and inferior milking cows usually eat more from the creep-feeder than do the other calves. When natural feed conditions are unfavorable, creep-feeding of calves indirectly helps the cow herd, as the calves do not draw so heavily on the cows during the latter part of the nursing period.

Good breeding in cattle is desirable in all feeding operations, but in creep-feeding calves for market finish, the well-bred calf of good quality is essential. The calves should be sired by purebred Hereford, Shorthorn, or Angus bulls of superior quality. The cows should be of at least average range quality.

Creep-feeding is adapted to pastures and ranges where the herd comes regularly to a central point for water, salt, shade, or rest. Also such ranges must be accessible to the grain wagon or truck. Creep-feeding is *impractical* on rough mountain ranges or on any range where cattle graze over vast areas and infrequently gather at a central point, or where transportation of feed is difficult.

Best results have been obtained with so-called "early calves," which

are started on feed before they are 3 months of age. This means calves dropped before the green-grass season. Such calves learn to eat grain early in the season, take full advantage of a heavy milk flow from the cows during the good-grass season, and by the time the grass is dried are ready to consume comparatively large amounts of grain. Calves will learn to eat grain when they are but 4 to 6 weeks of age. When the creep is constructed near the watering place, salt grounds, corral, or loafing ground of the herd, almost immediately some calves will enter it through curiosity; others will soon follow, and, after a few calves have started to eat, nearly all of them will follow the leaders.

During the early part of the creep-feeding period, the ration should contain a variety of good-quality grains or grain substitutes. When the calves are young, the grass green, and cow's milk abundant, protein supplements are not necessary. After the grass is dry and the milk is decreased, it is well to include one part pea-sized cottonseed cake or meal to every 10 or 12 pounds carbonaceous feeds. If fish meal is substituted for cottonseed cake or meal, about one third less is required to provide the necessary protein. Linseed meal may substitute for cottonseed meal pound for pound. If the cows and calves are on good-quality pasture, it is not customary to provide hay in the creep-feeder. When grazing conditions are poor and forage is of low quality or scarce, good-quality alfalfa meal or alfalfa-molasses meal will be of material benefit when added to the concentrate mixture in the self-feeder. High-quality long alfalfa hay may also be fed in a separate rack alongside the self-feeder. When silage is near at hand, it may be found a practical and beneficial feed to use during the creep-feeding period, especially when grass or dry roughage consumed is of poor quality.

In creep-feeding calves for the first time, stockmen are apt to grow impatient at the seemingly slow progress made for the first two or three months; by this time, however, the results become more evident.

Experience has shown that where calves are being finished for market, the self-feeder is usually more practical to use than hand-feeding in troughs.¹² The openings in the creep fence should be made for the calves to go through. Sometimes a fence is so constructed as to permit the calves to crawl under, and this is not so satisfactory. Rarely will any trouble from overeating be experienced in self-feeding if the calves have been taught to eat grain when they are but 2 to 3 months of age. When feeding is delayed until the calves are older, difficulty from overeating may result if self-feeders are used. When the calves are weaned and brought into the feed lot, the same self-feeder can be moved into the lot.

¹² Plans for the construction of a calf-creep and self-feeder are available from the Agricultural Extension Service, University of California, Berkeley, California.

Weaning creep-fed calves is a simple matter. The calves are advanced enough in the feeding period so that they do not miss their mothers, and no setback is experienced if they are continued on feed with no radical change in the ration. Stockmen have been surprised to see how these calves maintain their "milk-fat" bloom after weaning.

The results of fattening several different lots of calves which were creep-fed before weaning are summarized in table 13.

NECESSARY MARGIN OR SPREAD

If feeder cattle are purchased or valued at \$7 per hundredweight and must sell when fat at \$9 in order to "break even" on the feeding enterprise, the difference of \$2 is usually referred to as the necessary margin or spread. The discussion that follows shows the principal reasons for the wide variation in the margin necessary for cattle-fattening operations.

In pasture fattening of cattle the cost of producing 100 pounds gain is very often less than the sale price per hundredweight of the cattle when fat and sometimes less than the value per hundredweight of the cattle at the beginning of the feeding period. In feed-lot fattening of cattle, however, the cost of producing 100 pounds of gain usually *exceeds* the selling price per hundredweight of the cattle and profit must be derived from enhancing the value of the feeder weight of the animals. Under very favorable price relations between cattle and feed and when good gains are made, the cost of 100 pounds of gain in the feed lot may be less than the selling price of the cattle.

Numerous items must be considered in computing the cost of producing gain. The major item is the feed cost of gain. Other items are labor, interest, depreciation, taxes, mortality risk, transportation, and marketing costs. Many cattle feeders consider the value of the fertilizer produced by the cattle to be equal to the labor charge. In some instances fertilizer credit may be sufficient to offset other minor costs in addition to labor.

When considered separately and independently, the effect of each of the principal factors on cost of gain and consequent necessary margin is as follows:

1. A greater cost or value of the feeder cattle per hundredweight tends to lessen the necessary margin because the original cost more nearly approaches the cost of producing gain.

2. A greater weight of the animals as feeders tends to reduce the necessary margin because more pounds of original weight are sold at the final price. Any advantage from greater weight of older animals may,

TABLE 13
RESULTS OF FINISHING CALVES WHICH HAD BEEN CREEP-FED DURING THE NURSING PERIOD*

Animals fed	Average daily ration, pounds	Average initial weight, pounds†	Average daily gain, pounds	Pounds feed consumed per 100 pounds gain
61 steers and 34 heifers fed together both periods.....	Creep-feeding period of 193 days.....	....	....	....
	{ Concentrates.... 3.1 { Silage (48 days).... 5.0	....	....	....
	Feed-lot period (after weaning) of 133 days.....	480	2.16	{ Concentrates..... 559 { Hay..... 165 { Silage..... 338
	{ Concentrates.... 12.1 { Hay..... 3.6 { Silage..... 7.2	....	....	....
39 steers and 39 heifers fed separately in feed-lot period.....	Creep-feeding period of 109 days.....	....	....	....
	{ Concentrates.... 2.3	....	....	....
	For steers, feed-lot period (after weaning) of 175 days.....	332	1.95	{ Concentrates..... 524 { Hay..... 327
	{ Concentrates.... 10.3 { Hay..... 6.4	....	....	....
39 steers and 26 heifers fed separately in feed-lot period.....	For heifers, feed-lot period (after weaning) of 180 days.....	314	1.83	{ Concentrates..... 541 { Hay..... 331
	{ Concentrates.... 9.9 { Hay..... 6.1	....	....	....
	Creep-feeding period of 115 days.....	....	....	....
	{ Concentrates.... 2.2 { Silage (55 days).... 5.8	....	....	....
For steers, feed-lot period (after weaning) of 202 days.....	{ Concentrates.... 8.1 { Hay..... 7.2	398	1.63	{ Concentrates..... 496 { Hay..... 444
	For heifers, feed-lot period (after weaning) of 184 days.....	375	1.51	{ Concentrates..... 484 { Hay..... 432
	{ Concentrates.... 7.3 { Hay..... 6.6	....	....	....

* Agricultural Extension Service (Ventura County) summarized report of creep-feeding demonstration on Rancho Matlija, Ojai, Calif. 1935.

† No weights obtained at start of creep-feeding period.

however, be more than offset by their requiring more feed to produce gain than would younger or lighter animals.

3. The production of maximum gain from each unit of feed can effectively aid in lowering the necessary margin. The stockman through good judgment and skill can influence this important item more than any other.

4. A lower cost for feed per ton of digestible nutrients and a smaller overhead cost obviously tends to reduce the necessary margin.

TABLE 14
THE EFFECT OF VARYING PRICES OF FEEDER CATTLE AND FEED ON
NECESSARY MARGIN*

Cost of feed per ton	Necessary margin at a given cost of feeder cattle per hundredweight								
	\$4.00	\$5.00	\$6.00	\$7.00	\$8.00	\$9.00	\$10.00	\$11.00	\$12.00
\$10.00	\$0.78	\$0.50	\$0.22	\$-0.07	\$-0.35	\$-0.63	\$-0.91	\$-1.20	\$-1.48
12.00	1.17	0.88	0.60	0.32	0.04	-0.25	-0.53	-0.81	-1.09
14.00	1.55	1.27	0.98	0.70	0.42	0.14	-0.15	-0.43	-0.71
16.00	1.93	1.65	1.37	1.08	0.80	0.52	0.24	-0.05	-0.33
18.00	2.31	2.03	1.75	1.47	1.18	0.90	0.62	0.34	0.05
20.00	2.70	2.41	2.13	1.85	1.57	1.28	1.00	0.72	0.44
22.00	3.08	2.80	2.51	2.23	1.95	1.67	1.38	1.10	0.82
24.00	3.46	3.18	2.90	2.61	2.33	2.05	1.77	1.48	1.20
26.00	3.84	3.56	3.28	3.00	2.71	2.43	2.15	1.87	1.58
28.00	4.23	3.94	3.66	3.36	3.10	2.81	2.53	2.25	1.97
\$30.00	\$4.61	\$4.33	\$4.04	\$3.76	\$3.48	\$3.20	\$2.91	\$2.63	\$2.35

* Necessary margins shown in the table are based on the following assumptions: A 700-pound feeder steer, fed 150 days to attain 1,000 pounds weight after consuming feed at the rate of 3 pounds daily per 100 pounds live weight or a total of 3,825 pounds of feed. Charges include the cost of the steer, 6 per cent interest on the cost of the steer, and the cost of the feed, but they do *not* include such items as labor, equipment costs, mortality, and taxes.

The manner in which all these factors combine will finally decide the necessary margin in fattening cattle.

Since prices of feeder cattle and feed are the most variable among the important factors governing necessary margin, table 14 was compiled to illustrate how greatly these two factors do affect the margin. To arrive at the margins shown in the table the following constants were arbitrarily selected :

It was assumed that a 700-pound steer was fed for 150 days, made an average net daily gain of 2 pounds, and attained a net sale weight of 1,000 pounds when fat. The average weight of the steer during the feeding period was 850 pounds and the animal consumed daily 3 pounds of concentrates and dry roughage per 100 pounds average weight. The assumed rate of gain and feed consumption are based on numerous actual records of fattening cattle under practical feed-lot conditions.

In computing costs and determining the different required margins shown in table 14, the charges included cost of the steer, cost of the feed,

and interest on the purchase cost of the steer for 5 months at 6 per cent. Charges did *not* include such items as death loss, equipment costs, taxes, and labor; nor was any credit allowed for manure.

Table 14 brings out three significant points which have long been recognized by experienced cattle feeders:

1. The most favorable situation in respect to necessary margin is when the feeder cattle market is at a relatively high level and the prices of feeds are at a very low level. Under these conditions if good feeding practices are followed even feed-lot operations sometimes show a profit when no margin exists between the price paid for feeder cattle and their sale price when fat.

2. A greater margin is required when the price levels of both feeder cattle and feeds are low than when the feeder cattle market is high and feed market is low; less margin is necessary, however, when both feeder cattle and feeds are at a low level in price than when both are at a high level.

3. The least favorable situation of all in respect to necessary margin is to have a low feeder cattle market and high-priced feeds. When such a price relation prevails, a margin of \$4 per hundredweight, or even more, may not be sufficient for the cattle-feeding enterprise to break even.

By careful planning to bring proper adjustment between feeds to be used, cattle to be fed, and feeding practices to be employed, the cattle feeder can often materially reduce his necessary margin and enhance his chance for greater profit. Such planning calls for a knowledge of the adaptability, requirements, and limitations of the various classes and grades of cattle. It necessitates an understanding of feeds and their values and requires good business judgment on the part of the stockman. The information and recommendations in this circular will serve as reference material for the operator when planning a cattle-feeding program that is adapted to his own ranch or feed-lot conditions.

